

Tools and Autonomy Technologies for Scientific Instrument Targeting M. Battler¹, K. Raimalwala¹, A. Macdonald¹, M. Cross¹, M. Faragalli¹, ¹Mission Control Space Services Inc., 162 Elm St. West, Ottawa, ON Canada, melissa@missioncontrolspaceservices.com

Introduction: Commercial lunar missions will face several constraints such as limited onboard power, computational and downlink capacity, mobility performance, and will be short-lived without lunar night survival technology. In a traditional mission architecture, rover imagery and telemetry are downlinked to Earth at a constrained data transfer rate, where ground-based operators must make decisions after a series of steps in data processing and analysis. With these constraints in mind, it is imperative that scientific instruments can collect key measurements as efficiently as possible, leading to a demand for operator tools and onboard autonomy techniques that can streamline the instrument targeting process. Our instrument targeting autonomy technology is based on our capability to identify common lunar surface features such as rocks and craters that are defined by the instrument science team.

Autonomous Targeting Based on Visual Identification of Lunar Surface Features: Any intelligent decision-making process onboard will require a semantic representation of the terrain [1]. Mission Control has developed technology to classify known geological features at a macro-level as seen in standard colour images or identify features considered rare or novel on the lunar surface, using deep learning models (convolutional neural networks) [2]. Figure 1 shows an example output from our classifier that can detect craters, boulders, and other surface features.

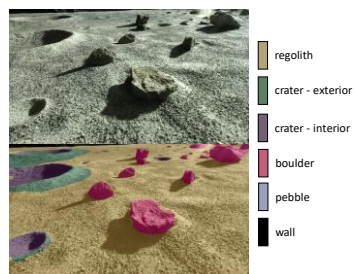


Figure 1. Example output of our latest terrain classifier, processing an image taken from our lunar analogue testbed.

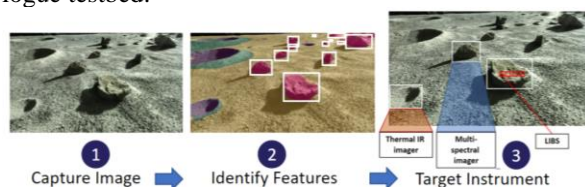


Figure 2. Illustration of how autonomously identified features can be targeted by scientific instruments.

Operator Tools: For operators, Mission Control has developed web-based operations interfaces to enable payload command and control for distributed teams.

A recent example is the integration of a pan-tilt-zoom (PTZ) camera controller within our rover operations interface, allowing one or more operators to control payloads. This user interface has been used in several analogue campaigns by Mission Control, including a successful demonstration to advance to the final round of the ESA-ESRIC Space Resources Challenge.



Figure 3. A view of our rover control user interface that includes a PTZ camera and image capture controller.

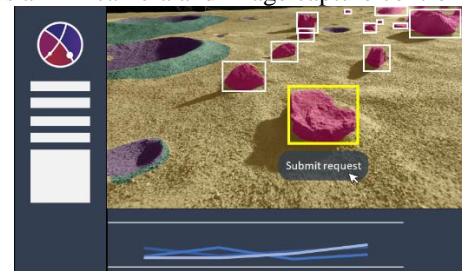


Figure 4. A mock-up of a user interface that can support processing autonomously identified features for tasks such as instrument target requests.

Lunar Surface Demonstration: In early 2023, Mission Control will demonstrate AI-based identification of lunar surface features; our AI model will be embedded on a high-performance and compact flight processor integrated on the ispace lander for the M1 mission launching in 2022. It will process images from the Rashed rover as part of the Emirates Lunar Mission (ELM). The data products will be downlinked to Earth, and be used to inform rover path planning. ELM is led by the Mohammed Bin Rashid Space Centre (MBRSC).

In future missions, such technology can be leveraged for onboard decision-making to enable autonomy for rover navigation, instrument targeting, data downlink prioritization, actuation of robotic arms or other devices for sample collection, and other tasks.

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References: [1] Francis R. et al. (2014) *SpaceOps*. [2] Raimalwala K. et al. (2020) *i-SAIRAS*. [3] Faragalli M. et al. (2021) *IAC*.