Enabling Autonomous Lunar Surface Robotics with Artificial Intelligence. K. V. Raimalwala[1], M. Faragalli[1], M. M. Battler[1], and M. Cross[1]. [1]Mission Control, 162 Elm. St. W., Ottawa ON K1R 6N5, Canada, kaizad@missioncontrolspaceservices.com

Introduction: As commercial missions to the Moon pave the way for near-term efforts to establish permanent infrastructure, it is well understood that the lunar economy should grow increasingly self-reliant in contrast to Earth-centric missions that have been the norm so far. Similar to ISRU goals to use resources in situ, self-reliant mission architectures must increasingly use on-site computing to enable real-time autonomous robotics with AI applications. This is critical for these reasons:

1. Communications latencies of up to 10 seconds round-trip make real-time operations that rely on Earth-based decision-making unfeasible.
2. Communications drop-outs can be expected or unexpected due to technical or environmental circumstances. In either case, robotic and crewed architectures can benefit from on-site computing to process and store data and provide actionable insights for real-time decisions.
3. Communications data transfer constraints. The data pipeline between the Moon and the Earth is constrained, and returning high-volume data to process on Earth for supporting real-time operations is not feasible. While this pipeline is expected to grow, so will the ecosystem of lunar spacecraft that use it.

Flight Demonstration of Supporting Lunar Surface Robotics with AI: In 2022, Mission Control will demonstrate an Edge Computing approach to support navigation for the Rashid micro-rover in the Emirates Lunar Mission led by the Mohammed Bin Rashid Space Centre (MBRSC) [1]. Our AI technology, integrated on the lander, will extract operationally relevant information from images streamed back from Rashid.

This demonstration will highlight how distributed computing can augment the autonomy of spacecraft systems that are otherwise designed to rely on Earth-based operations teams for certain tasks, paving the way for autonomous lunar surface infrastructure development.

The primary investigation will demonstrate the feasibility and usefulness of automated terrain classification for science and navigation operations using deep learning models embedded on a compact and high-performance flight-ready processor that may be integrated on the mission's lander spacecraft. The classifier will identify high-level surface features in images from the rover's navigation camera and downlink the outputs to science teams, to be used in rapid terrain assessment for science and navigation decision-making. This is targeted to be the first demonstration of Deep Learning on a lunar mission, unlocking potential applications for autonomous decision-making in future missions.

In addition to AI-based terrain classification, Mission Control will lead investigations in trafficability estimation, path planning, and power modeling for skid steer vehicles. The data from Rashid will be used to train the terrain classifier, whose outputs can then be used to intelligently estimate rover wheel slip hazards and power consumption.

Supporting Lunar Excavation & Construction Activities: To enable efficient uncrewed excavation and construction activities, vehicles and other systems must operate to a high degree of supervised autonomy as direct tele-control is unfeasible due to communications latencies and possible drop-outs. Ideally, Earth-based operators can uplink high-level objectives that these systems can parse to identify and execute tasks [2]. Any autonomous system executing tasks in the domain of lunar excavation and construction must also be able to understand its environment and the objects they are interacting with, known in robotics terms as 'perception'. This is essential to support safe and efficient task planning and execution. The state of the art in perception techniques involves using computationally intensive deep learning models to identify patterns and extract knowledge from sensor data such as camera images [3]. For example, an outfitting machine that outfits structures with cabling and other components must be able to identify the objects it works with, the geometry of its working space, and ideally also whether a task was successful or if it induced any problems.

Our demonstration of using AI on the lunar surface can enable these algorithms for scene reconstruction, object identification, hazard classification, and other perception capabilities, to support autonomous robotics systems in lunar infrastructure development.

References:

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