Enabling ARTEMIS and the FARSIDE Low-Frequency Radio Telescope missions with URSSA – a Testbed for extra-planetary Surface Telerobotics research. Midhun S. Menon[1], Daniel Szafir[2,3] & Jack. O. Burns[1], [1]Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, [2]Department of Computer Science, University of Colorado, Boulder, [3]ATLAS Institute, University of Colorado, Boulder. (midhun.menon@colorado.edu)

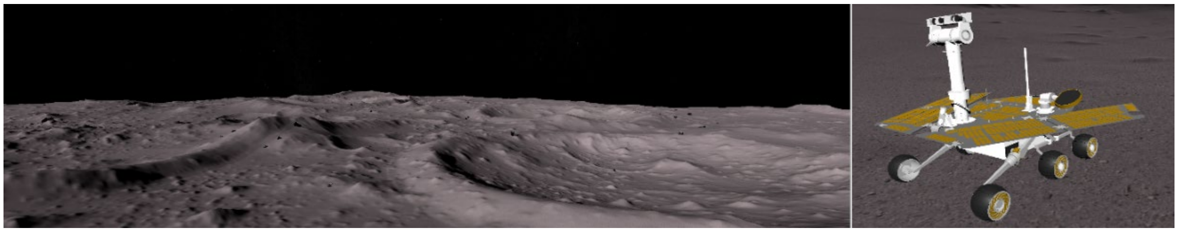

Figure 1. Snapshot of the terrain inside simulator (Left), Rover model in the simulator environment (Right)

Introduction: Experimental evidence of trapped ice within the lunar poles and the possibility of life on Mars have been two seminal discoveries of the last several decades. These discoveries have the potential for making sustainable research bases on these terrestrial bodies using In-Situ Resource Utilization (ISRU) a reality which in turn has resulted in space-faring nations announcing elaborate plans for new expeditions to the Moon and beyond.

It is not mere coincidence that both the above-mentioned groundbreaking discoveries were done with the assistance from teleoperated scouting and prospecting vehicles deployed in orbit or on the surface of the respective bodies. The proposed new missions are highly construction and surface-activity intensive and robots are expected to play an even bigger role including but not limited to precursor missions, teleoperation and real-time collaborative operation with astronauts.

However, designing and testing robotic systems for such partially observed environments and non-terrestrial environments remains an open problem. The challenges include the lack of Earth-based analogs, and the economics and logistics. In this paper, we propose an in-house simulation framework URSSA (Unity-ROS Simulator for Space Applications) as a virtual testbed to design and train such systems for extraterrestrial environments.

URSSA: The URSSA architecture is shown in Figure 2. It uses the Unity game engine for simulating the three-dimensional planetary surface environment. The Robotic Operation System (ROS) is used to simulate the robot interacting with the environment. These are isolated from each other and communicate via JSON messages sent over WebSocket. The ROS-Unity bidirectional communication is implemented using ROS# framework. This kind of modular architecture makes the system scalable. This paper discusses a specific case-study of modelling the lunar environment for specific application to the FARSIDE low radio frequency array mission proposal. The lunar photometry is simulated using custom made Hapke shaders which capture Moon-specific photometric anomalies like Opposition Surge. Lunar topography is modelled by using the Digital Terrain Model (DTM) generated from photoclinometry of LRO-NAC imagery as the baseline. Resolution of this synthetic landscape is augmented by adding smaller-scale surface structures and features using fractal expansion algorithms with observed roughness parameters from earlier landed missions. Figure 2 provides a snapshot from the simulator.

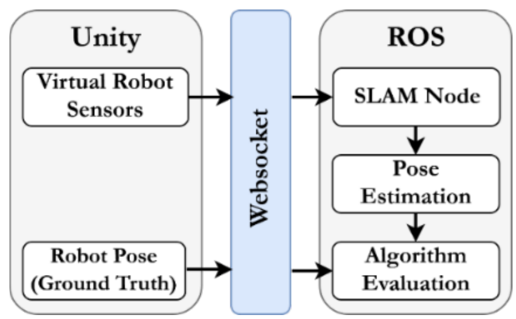

Figure 2. URSSA system architecture

Algorithm Tested: Various publicly available implementations of a class of navigation algorithms called SLAM (Simultaneous Localization And Mapping) are examined using forty test cases in which the sun-camera geometry, shader parameters (and hence terrain reflectance, opposition surge) and rover path (straight/ circular) are changed to evaluate algorithm performance in multiple conditions.

Results: Our results point to the fact that algorithms fail when used in a featureless environment like the Moon. They also indicate strong dependence of navigation errors on shader parameters. Both the observations illustrate the importance of designing and testing algorithms in lunar environments, reiterating the need for developing such simulators.

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