MIXED REALITY INTERFACES FOR THE MOON AND BEYOND: ADVANCING SURFACE TELEROBOTIC INTERFACES IN THE NASA ARTEMIS PROGRAM. M. E. Walker, J. O. Burns, D. J. Szafrir. Center for Astrophysics and Space Astronomy, University of Colorado (michael.walker-1@colorado.edu, jack.burns@colorado.edu, daniel.szafrir@colorado.edu).

Introduction: Since the advent of Mars exploratory missions with the robotic rovers of Spirit and Opportunity, considerable hardware and software advancements have been made to provide robots with improved capabilities to better explore space’s hostile environments. Unfortunately, the interfaces (e.g., the means in which scientists interact with such robots and take advantage of their full set of state-of-the-art features) have not seen the same level of development and technological advancement as the robots themselves. The high-level design of these interfaces has largely remained the same for decades, forcing scientists to view the rich, three-dimensional data returned by exploratory robots on outdated, two-dimensional monitors.

HMD Teleoperation Interfaces: Next generation HMD-based mixed reality (MR) teleoperation interfaces that harness the full dimensionality of our world are currently positioned to reshape robot-mediated space exploration and can merge both real and virtual worlds. These advances are providing an opportunity for a new design space: distal robot teleoperation mediated by MR HMD interfaces.

Immersive Teleoperation Interfaces: By utilizing the stereoscopic displays built into these headsets, operators are able to see from the robot’s perspective through live stereo video feeds with complete depth and immersion, unlike that of traditional two-dimensional monitors. Operators virtually embody the robot and are able to feel as if they’re actually looking out of the ‘eyes’ of the robot. Research has found that the immersion provided by VR HMD robotic interfaces improves efficiency and situational awareness without increasing the workload of operators, even in the case of multi-agent systems [1]. Through research in this design space, interface developers can learn how to best leverage the inherent benefits VR HMDs have to offer, in the context of robotic space exploration.

Multi-Perspective MR Teleoperation Interfaces: To fully examine the full capabilities that HMD technologies afford; our research will examine multi-perspective MR HMD interface designs. Both egocentric (1st person) and exocentric (3rd person) designs will be explored to examine overall effectiveness as well as optimal use cases for either design paradigm.

We hypothesize interfaces will offer significant operational advantages if a robot operator can switch, at will, between egocentric and exocentric perspectives. In this second exocentric view, the user can physically walk around a 3D representation of the robot(s) in virtual space, situated within a live RGB point cloud of the robot(s)’s current environment. This would essentially allow users to ‘step out’ of the robot’s body and use their own body and head movements to change their viewpoint to gain better situational awareness of the robot’s pose relative to its environment, such as terrain hazards or areas of scientific interest. An interface such as this would additionally mitigate occlusion issues, where the robot chassis obstructs the operators view at various viewing angles.

With the development and utilization of advanced teleoperation interfaces, such as those featuring augmented virtuality [3] described above, scientists will be better equipped to leverage the full capabilities of their robots and learn more about both the lunar environment and the early universe without the need of a physical human presence.

Acknowledgments: This work was directly supported by the NASA Solar System Exploration Virtual Institute Cooperative Agreement 80ARCC017M0006.

References: