University of Colorado Boulder

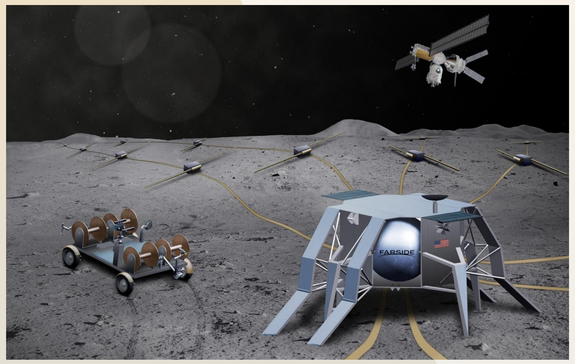
NESS Network for Exploration and Space Science

Construction of Lunar Infrastructure Leveraging Low-Latency VR/AR Teleoperation

M. Bell, P. Curlin, M. Muniz, J. Burns

Introduction

NASA is working to return humans to the Moon, creating a sustainable human lunar presence, by 2024. Alongside this mission, NASA has begun construction of the Gateway, soon enabling low-latency robotic operations on the lunar surface. Our research team is involved with the scientific mission FARSIDE, a NASA funded concept that would place a low radio frequency interferometric array on the farside of the Moon. Missions such as FARSIDE may require the robotic deployment of infrastructure and real time human-robot operations. Furthermore, lunar missions leveraging robotic teleoperation will also require new methods of failure recovery.



Research Objectives

- Simplify the process of planetary robotic failure recovery
- Develop a risk-free and real-time failure response method leveraging cutting edge virtual technologies through our virtual recovery sandbox and telepresence interface

The Armstrong Rover

Equipped with a 6 DOF Crustcrawler Pro-series Robotic Arm, differential drive base and ZED Mini (stereoscopic camera), Armstrong is the perfect candidate for lab experiments to validate solutions developed in the virtual recovery sandbox.

The ZED Mini supports an operator telepresence interface to best represent the state of real-time remote teleoperation.

Rendered image of the Armstrong rover. This model is physically accurate for use in the virtual recovery sandbox

Expanding Teleoperation

Telepresence uses virtual technology to allow a remote operator to feel as if they were present in the rover's environment. This has been proven to maximize information to the human operator, as it increases situational awareness and provides an immersive and detailed environment for the operator. Our physical telepresence implementation leverages a high-definition stereo-camera stream to the operator HMD with POV tracking. This technology can also be leveraged to generate virtual space representing the robot's current state and environment through 3D scans. This allows for the development of virtual simulations, accessible in real time, for teleoperators to gain information communicated from the physical robot in a risk-free environment.

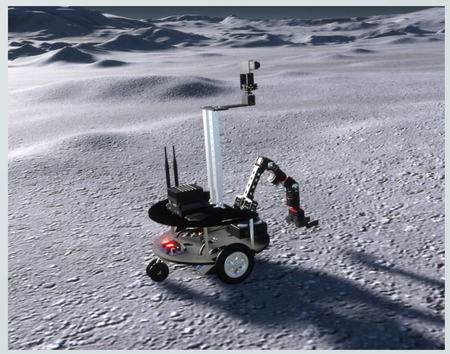
Armstrong's telepresence interface. Two servo motors help to mimic the teleoperator's viewpoint by tracking the HMD's orientation

Egocentric Control

- VR headset viewing through the "eyes" of the virtual rover; The rover's stereo camera stream
- Rover manipulation

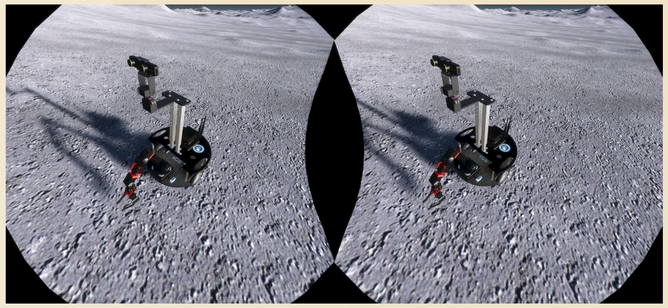
Exocentric Observation

- Free-moving 3rd person perspective
- Enabled through 3D scans from the robot
- Accessible within the virtual recovery sandbox in situations where the operator cannot be locally present with the robot



Virtual Recovery Sandbox

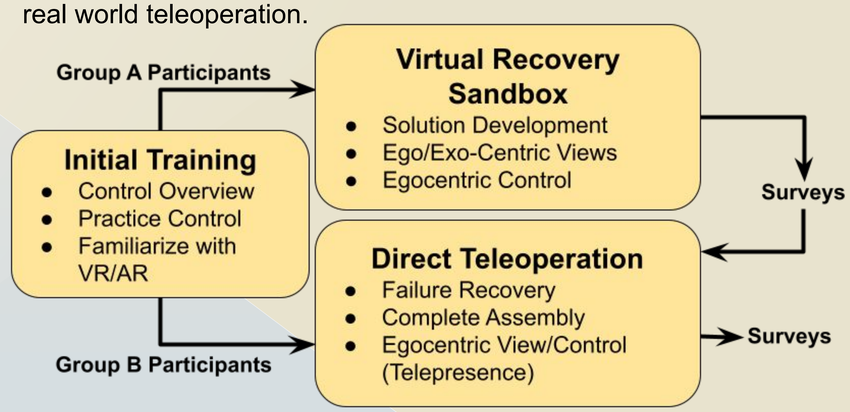
Our experimental virtual recovery sandbox leverages high-fidelity virtual models of the Armstrong rover. Software interfaces are identical between our virtual and physical rover to create a transferable operation experience. Environments may be developed through virtual modeling or 3D scans taken from the physical rover. Within the sandbox, operators are provided a risk-free space with access to both egocentric control and exocentric observation interfaces to develop solutions to various robotic failures.



Ocular view of the Armstrong rover in a virtual simulation space

Assessing Virtual Solution Development

Through experimental process, we aim to validate the effectiveness of solutions developed for robotic failures in our virtual recovery sandbox. By providing participants time to create solutions in the virtual recovery sandbox prior to taking control of the physical rover, we can prove that the skills and solutions developed translate to real world teleoperation.



Possible failures seen within FARSIDE may include situations requiring teleoperators to adjust the alignment of of polarization axes of deployed dipole antennas on the surface.

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