MIXED REALITY INTERFACES FOR MOBILE LUNAR SURFACE ROBOTS

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Motivation

Interfaces that scientists use to interact with planetary surface robots have not seen the same level of development and technological advancement as robot hardware and software.

The design of robot interfaces has largely remained the same for decades, forcing scientists to view the rich 3D data returned by space exploratory robots on outdated 2D monitors.

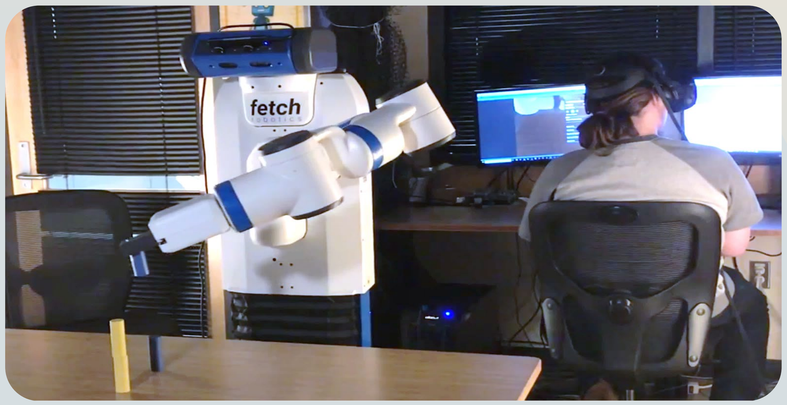
CU Boulder NESS Team's Proposed Research

Provide further justification for the inclusion of virtual reality (VR) and mixed reality (MR) infrastructure in future space missions leveraging concepts from the field of human-robot interaction.

See demo video at https://youtu.be/cJ8f7zlzWc0

HMD Teleoperation Interfaces

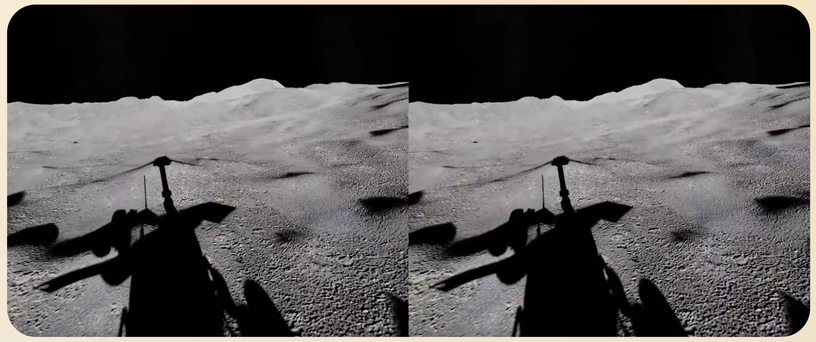
Head-mounted displays (HMDs) operate in 3D and MR HMD technology advances have opened a new design space for robot teleoperation interfaces.



Immersive Teleoperation Interfaces

Stereoscopic displays built into HMDs allow operators to virtually embody the robot as if they're looking out of its 'eyes.'

Immersion provided by VR HMD interfaces improves efficiency and situational awareness without increasing the workload of operators, even in multi-agent systems [Roldan, et al. 2017].

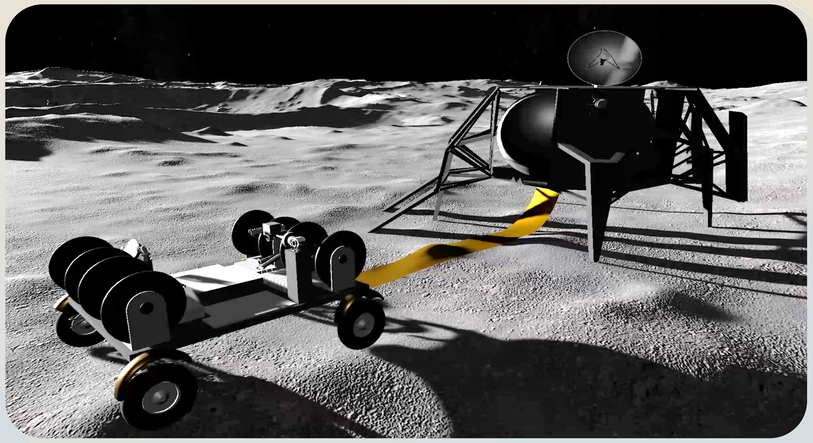


Multi-Perspective MR Teleoperation Interfaces

Our research will examine multi-perspective MR HMD interface designs for lunar surface telerobotic missions:

- **Ego**centric Interfaces (1st person)
- **Exo**centric Interfaces (3rd person)

We hypothesize that interfaces with at-will switching between 1st and 3rd person perspectives will significantly improve telerobotic surface assembly and navigation operations.



Use cases for telerobotic MR HMD interfaces include the assembly and deployment of low frequency radio telescopes on the far side of the moon [Burns, et al. 2019].

See concept video at https://youtu.be/5hTZGp4zib4

A Collaborative Mixed Reality Interface

Additionally, we will examine how MR interfaces can facilitate multi-user collaboration for teleoperation planning and live missions.

Our proposed interface would provide robot teleoperators with a shared virtual space to supervise and control remote robots on the lunar surface while pulling design aspects from both:

- **Virtual Control Room** Teleoperation Interfaces
- **Cyber-Physical** Teleoperation Interfaces

Conclusion

Next generation HMD-based MR teleoperation interfaces that harness the full dimensionality of our world are currently positioned to reshape robot-mediated space exploration.

With the development and utilization of advanced teleoperation interfaces, such as those featuring cyber-physical augmented virtuality and at-will switching between 1st and 3rd person perspectives 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.

Our prototype MR teleoperation interface that unifies concepts from both virtual control room interfaces and cyber-physical interfaces by providing mobile space robot operators with egocentric (live 3D video stream) and exocentric (3D environmental construction in the form of a dense point cloud) perspectives.

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