Lunar telerobotic assembly recovery using cyber-physical training

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Abstract. NASA is working to achieve the goal of returning humans to the Moon by 2024 and then create a sustainable human lunar presence by 2028. For humanity to create a sustainable lunar presence, well-developed collaborations between humans and robots are necessary to perform complex tasks such as surface assembly of radio telescopes and ISRU stations. Robots utilizing a collaborative control model will have the benefits of both autonomy and human ingenuity. Although these robots will be thoroughly tested before landing on the lunar surface, humans may have to directly control the robots to recover from a failure mode.

Currently, hardware duplicates of the Martian rovers are used to test solutions for failures. When Curiosity's drill feed mechanism exhibited anomalous behavior, NASA diagnosed the failure using a hardware duplicate in the Mars Yard.[1] While this method is expensive, time consuming, and possibly inaccurate, it is currently the most viable method for failure recovery of the Martian rovers. A sustainable human lunar presence will require large-scale lunar robotic operations, making this type of failure response very inefficient. The Gateway could provide infrastructure for large data transfer with minimal latency allowing for new failure response methods. When performing lunar assembly tasks, an autonomous robot would be able to detect if the end condition of the assembly task has been met. If the robot is unable to complete the assembly, direct teleoperation may be necessary. Assuming all assembly objects are marked, a 3D scan of the robot's environment can be converted into a cyber-physical failure recovery simulation where all unmarked objects are assumed to be terrain with uniform physical properties. This would allow the operator to test various recovery solutions in a cyber-physical sandbox before teleoperating the real robot.

Our research team is involved in designing the scientific mission FARSIDE (Farside Array for Radio Science Investigation of the Dark Ages and Exoplanets), requiring the use of intricate surface telerobotics.[2] FARSIDE is a NASA-funded concept that would place a low radio frequency interferometric array on the farside of the Moon. The mission design requires a rover to deploy antenna nodes from a lander onto the lunar surface. The technology that the Telerobotics Laboratory is currently developing could be leveraged to recover from deployment failures during the FARSIDE mission.

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