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DEPLOYMENT OF THE SOLEX ENVIRONMENT FOR ANALOG SPACE TELEROBOTICS VALIDATION

Abstract

Lunar and planetary colonization is gaining increasing interest in the space community, exemplified by ESA's Lunar Village Initiative. This requires detailed preparation of infrastructures in distant and hazardous environments. Furthermore, as infrastructures and habitats continues to be constructed and expanded in the future, assembly, repair, and maintenance tasks will become increasingly complex. Intelligent robots serving as co-workers can be the key to fulfill these challenges. They can assist the astronaut by easing their workload, particularly in mundane and repetitive tasks, as well as dangerous situations. Successful human-robot collaboration calls for effective user interface designs for astronauts and ground control, which can increase performance and reduce user fatigue.

An analog proving ground is a necessary tool of validation and verification to ensure proper robotic functionality prior to space deployment. Furthermore, it can also serve as an effective performance evaluation metric. This paper presents DLR's simulated Martian SOLar farm EXperimental (SOLEX) environment. It was designed for the METERON SUPVIS Justin space-to-ground telerobotics experiment, spearheaded by DLR and ESA. During 2017-2018, a total of five astronauts performed different protocols over three International Space Station (ISS)-to-ground sessions. A wide range of telerobotic capabilities were examined, including navigation, mechatronic device maintenance, object manipulation, to component retrieval and assembly. The astronaut issued contextually task-level commands via an intuitive tablet PC application. DLRs humanoid robot Rollin' Justin executed the respective commands autonomously and thus acted as the astronaut's remote co-worker.

The SOLEX environment was implemented with a Martian background to examine robot object recognition and navigation performance. It is equipped with a lander module and a fleet of DLR developed Smart Payload Units (SPU) to be utilized and serviced by the robot in the habitat. Each SPU can be reconfigured to serve different functions, such as solar energy collection, and cabled or wireless communication. Moreover, the SPU is able to record mechanical, electronical and software interactions to help provide a holistic robot performance evaluation and validation. The SOLEX environment is scalable for rapid deployment of a wide variety of experiments, thanks to its modular design. It provides the possibility to add various functionalities and the ability to rapidly enhance the experiment protocols. Although original designed for validation of supervised autonomy telerobotics experiments, the SOLEX environment can be used as proving ground for any form of robotic operation, from open loop command, haptically coupled telepresence to full autonomy of single robots or robotic teams.