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USING EXTENDED REALITY TO STUDY HUMAN-ROBOT COLLABORATION FOR LUNAR HABITAT CONSTRUCTION: A PILOT STUDY ON BLOCK DESIGN AND DISRUPTION MANAGEMENT

Abstract

Lunar habitat construction demands innovative approaches that transcend conventional Earth-based methods, particularly in the integration of robotic systems and human oversight. Current research being conducted at the Andy Thomas Centre for Space Resources (ATCSR) explores the application of Extended Reality (XR) as a simulation platform to examine Human-Robot Collaboration (HRC) in the construction of lunar habitats. A central concern of this study is to investigate how block design influences task and safety performance during robotic assembly tasks under simulated lunar conditions.

This paper presents the results of the pilot study, which evaluated two distinct block types: a conventional cuboid and an osteomorphic interlocking design across six classes of disruption events. These disruptions, including block misalignment, orientation errors, and dropped blocks (as well as combinations thereof), simulate real-world anomalies that necessitate human intervention via teleoperation. A Wizard of Oz approach is implemented to simulate autonomous robot behaviour, allowing participants to seamlessly transition into tele operative control from a supervisory role during off-nominal conditions. This pilot study, conducted as a tabletop experiment without the use of XR, informs the design of the subsequent phases of the research. Objective performance metrics, such as task performance and safety performance, are measured alongside subjective measures of cognitive workload, situational awareness and fatigue ratings.

Preliminary findings underscore the importance of block design in facilitating efficient human-robot collaboration and offer a promising pathway for advancing lunar construction methods. This study contributes to the broader discourse on Construction 4.0 and paves the way for further investigations into multi-modal communication strategies and extended-duration operations in lunar analogue environments. The preliminary results from the pilot study will be discussed in detail, alongside proposed refinements for upcoming phases of research, with the goal of developing scalable, safe, and efficient construction techniques for future lunar missions.