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EXTENDED REALITY FOR HUMAN-ROBOT COLLABORATION IN LUNAR CONSTRUCTION: A PRISMA SYSTEMATIC REVIEW

Abstract

With the renewed interest in lunar exploration through the Artemis and other programs, the establishment of sustainable infrastructure on the lunar surface has emerged as a critical challenge. Central to this endeavor lies the development of efficient construction methods that harness the complementary strengths of both humans and robots. However, current design and construction processes tend to be linear in nature and do not account for the latest developments in both immersive technologies and design thinking. Therefore, there is a growing need to rethink our approach to design and construction and propose a comprehensive solution that integrates design iteration, rapid prototyping, and testing into a new approach for lunar construction.

This paper presents a systematic review of relevant literature, using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, to identify the latest developments across a range of disciplines and define the research gaps. It will engage with the current literature on Lunar Construction including specific challenges of lunar context for robotic construction and the current state of virtual simulations to recreate these challenges for design and testing. It will further look at current literature in the field of Human-Robot Interaction, to identify the state-of-the-art in terms of robotic technology and human training solutions available. This will include recent developments in computer vision technology and machine learning to enhance production efficiencies, as well as examples of use cases in the Aerospace and Defence industries. There is also an emerging area of research for human-robot collaboration in design process which will be of great relevance and interest. Finally, the literature review will focus on the latest developments in Spatial Computing and Extended Reality (XR) - an umbrella term including augmented reality (AR), virtual reality (VR), and mixed reality (MR) – to demonstrate how these technologies are being engaged in the construction industry. With the implementation of Industry 4.0 protocols several new systems have emerged to integrate the processes of rapid prototyping and testing into the design phases and allow for better interaction between humans and robots during the process of construction.

By synthesizing existing knowledge and highlighting advancements, gaps, and opportunities across these domains of Lunar Construction, Human-Robot Interaction, and Extended Reality (XR), this paper aims to contribute not only to the discourse on space habitation but also reconsider the construction industry on Earth, as we rapidly transition into a robotic construction economy.