Immersive Virtual Environments for 3-D Printing Structures for Lunar habitat and Extreme Environment

Dean's Research Awards Poster Presentation

Munib Mir[1] (Lead Author), Muhammad Afnan[2], Rafiq Ahmad[3]
Department of Mechanical Engineering, University of Alberta
[1]moienudd@ualberta.ca; [2]mk23@ualberta.ca; [3]rafiq.ahmad@ualberta.ca

Principal Investigator: Dr. Rafiq Ahmad
rafiq.ahmad@ualberta.ca
www.rafiqahmads.com

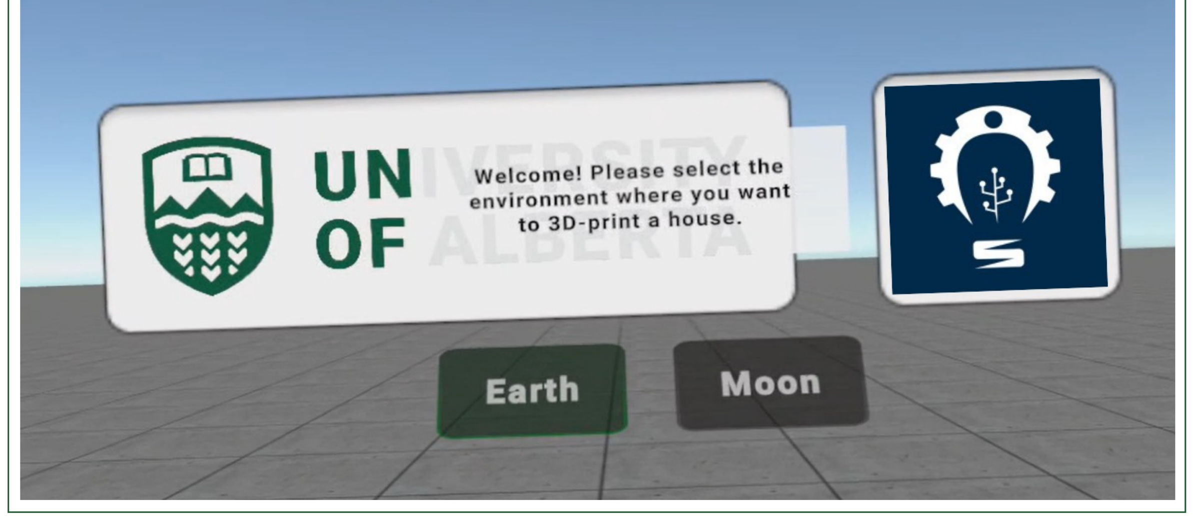
INTRODUCTION

BACKGROUND

The complexities of constructing and sustaining a lunar habitat under extreme environmental conditions pose significant challenges.

VISION

Modern augmented and virtual reality technologies simplify the process of interactive and realistic simulation of challenges that threaten safety. Our AR-VR game connects this gap through a virtual arena which teaches players about Moon habitat building methods and lets them evaluate fresh solutions and comprehend Moon settlement engineering challenges.



OBJECTIVES

Develop an Immersive AR-VR Environment

Create a virtual platform that accurately simulates the process of designing and building a sustainable Moon habitat.

Incorporate Realistic Lunar Constraints

Integrate factors such as low gravity, radiation exposure, and resource limitations to guide and validate habitat design choices.

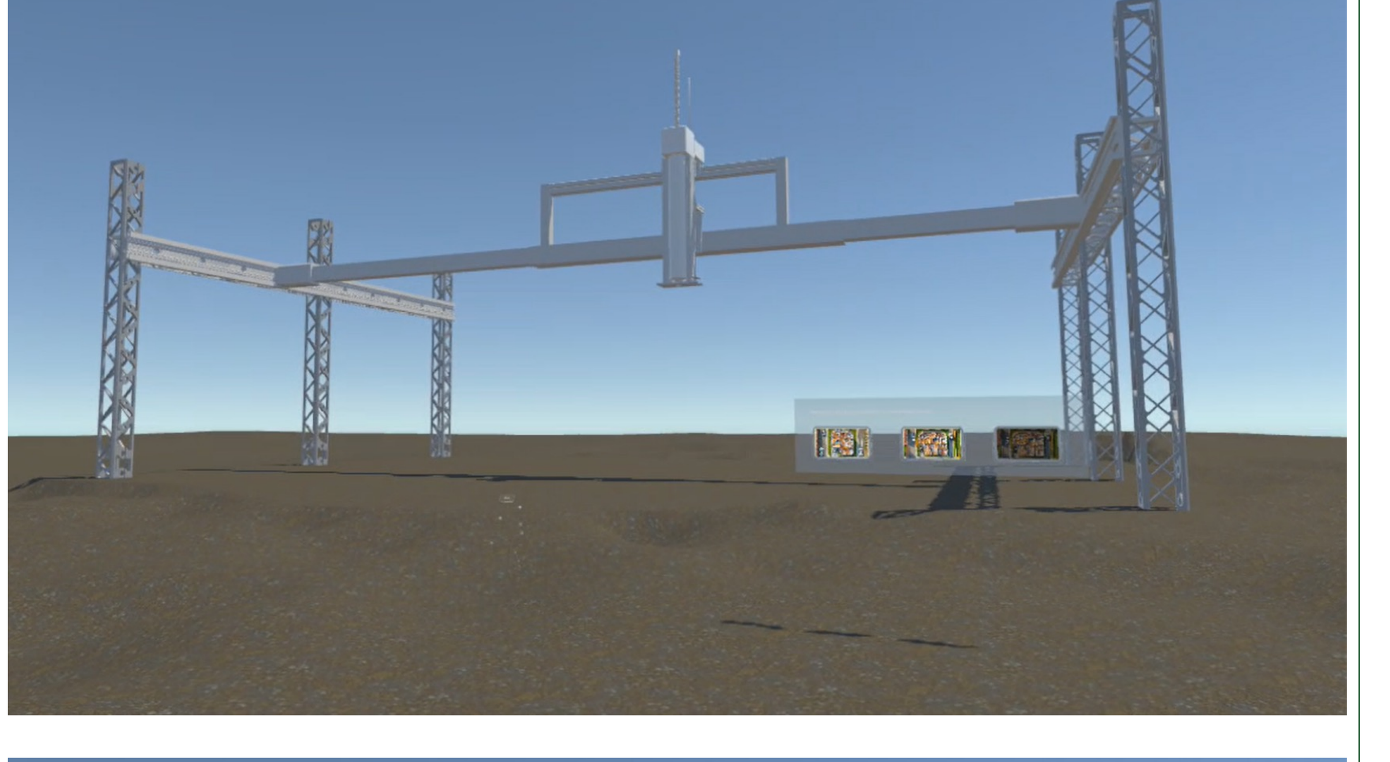
CURRENT WORK

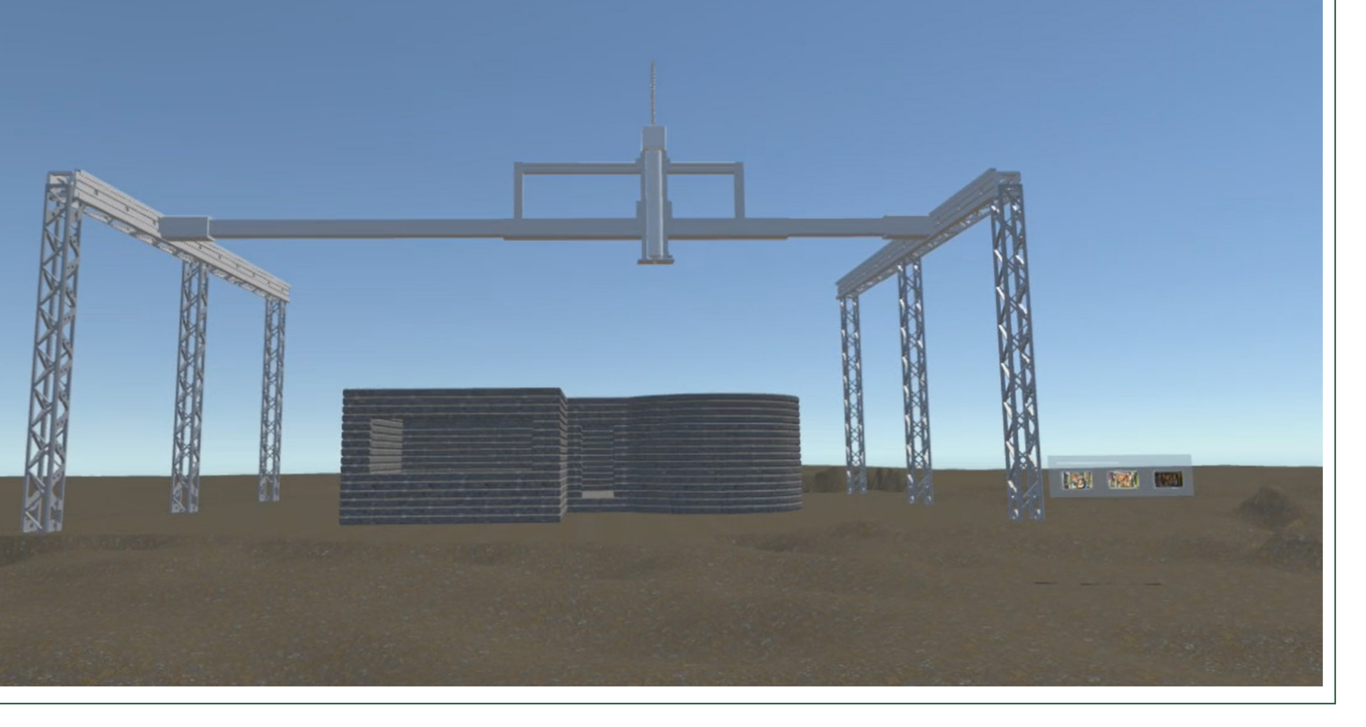
We have successfully created an initial AR-VR prototype that simulates core aspects of lunar habitat construction. This prototype includes:

Preliminary 3D Printing Simulation:
A basic environment that demonstrates layer-by-layer habitat assembly under lunar conditions.

User Interaction Mechanisms:
Pinch-based selection tools and motion controls for exploring and manipulating virtual construction elements.

Completed Earth Environment:
Our Earth based environment is fully developed, providing a realistic context and baseline for comparative analysis with the lunar habitat prototype.





PROPOSED METHODOLOGY

Environment Design & Setup:
Using Unity as the main game engine, we have created a realistic lunar landscape that simulates reduced gravity, lunar soil properties, and extreme temperature variations. Our existing Earth environment serves as a baseline comparison, allowing seamless switching between terrestrial and lunar settings.

AR-VR Integration:
We have implemented advanced VR gestures (pinch, grab, and throw) using the Unity XR Interaction Toolkit to enable realistic object manipulation. This immersive VR experience delivers a data-rich construction simulation, allowing users to interact intuitively with virtual construction elements.

3D Printing Simulation:
A layer-by-layer building logic that simulates the 3D printing of lunar habitats under realistic conditions. A dedicated interface tracks build progress, resource usage, and environmental impact in real time. This system offers a comprehensive view of the construction process from start to finish.

Conclusion & Acknowledgments

This project successfully developed an immersive AR-VR environment that simulates the process of designing and 3D-printing a lunar habitat, thereby bridging the gap between conceptual design and real-world constraints.

Professor Rafiq together with Muhammad Afnan made this work achievable through their constant valuable direction as the development progressed. I am also grateful for the opportunity to contribute to the innovative work at SMART Lab this term.

April 10, 2025,
University of Alberta 116st & 85 Ave,
Edmonton, Alberta

SMART LAB
SMART AND SUSTAINABLE MANUFACTURING SYSTEMS LABORATORY

UNIVERSITY OF ALBERTA