21st IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Sustainable Space Development and Settlement - Technologies (2B)

Author: Ms. Faith Tng
Space Generation Advisory Council (SGAC), Singapore, Republic of

Mr. Yun-Hang Cho
University of Sheffield, United Kingdom

EXPLORING OTHERWORLDLY DEPTHS: EVALUATING EARTH'S ROBOTIC CAVE EXPLORATION TECHNOLOGIES FOR SUBSURFACE EXPLORATION ON THE MOON AND MARS

Abstract

As space agencies around the world look to further explore the Moon and Mars, the role of robots is becoming increasingly important in navigating harsh space environments that pose threats to humans.

Subsurface environments such as lava tubes and caves have been found to exist on both the Moon and Mars. Due to their subterranean nature, potential astro-microbial life could be sheltered from the harsh surface radiation conditions. Therefore, subsurface environments may contain valuable scientific and resource information about biochemical signatures and geophysical activities that could inform past or present signs of extraterrestrial life.

However, these subsurface environments present new challenges different from exploring surface terrains. Firstly, navigating relatively unknown terrain and geological structures requires robots to be more adaptable with higher independence and autonomous decision-making. Secondly, with no direct line of sight to the surface, communication signals are attenuated limiting data bandwidth and may require a physical data wire to the cave entrance. Furthermore, the lack of sunlight in subsurface exploration imposes power constraints as solar power cannot be directly utilised. As cave exploration on Earth has been used as analogues for space missions and has dealt with similar challenges, the robotic technologies and methods used to access terrestrial caves may prove useful for exploring planetary caves.

This paper aims to investigate the potential of using current robotic technologies developed for cave exploration on Earth, towards exploring subsurfaces on the Moon and Mars. It will first review current cave exploration technologies such as Remotely Operated Vehicles (ROV), Unmanned Aerial Vehicles (UAV), Ground-based Robotics and other equipment, followed by an analysis of their strengths and weaknesses. By studying the unique characteristics of lunar and martian subsurface environments and the technologies used to explore them, this paper will assess the feasibility and benefits of applying these methods to subsurface exploration on other planetary bodies. Finally, the paper will propose further areas of development or research to help inform future plans for subsurface exploration on other celestial bodies.