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PANGOLIN SWARM ROBOTICS FOR LUNAR HABITATS: EXCAVATING UNDERGROUND STRUCTURES ON THE MOON

Abstract

The Artemis program by NASA is paving the way for long-term human presence on the Moon, with lunar habitats playing a crucial role. Swarm robotics is gaining increasing attention for in-situ space exploration, with workshops and sessions discussing the benefits, challenges, and applications of this approach. As part of the Spaceonova's Robotic Internship and Training Program, a spinoff idea to highlight the promising alternative of swarm robotics, allowing for the rapid and efficient excavation of lunar regolith to create underground habitats was worked to demonstrate the feasibility of this approach.

The discovery of lava-tube skylights, underground structures identified as pits on the lunar surface, which are said to be geological doorways to subterranean tunnels once filled with lava are crucial for human lunar habitats. Due to their ability to provide protection from the extreme lunar environment, these sites are regarded as critical locations for future human settlements or bases. This paper explores the potentiality of swarm robotics for excavating underground structures on the Moon, with a focus on caved-in type lava tubes for the construction of lunar habitats using technology inspired by the coordinated behavior of social insects and animals. This type of lava tubes are similar to those found in Hawai'i and other volcanic regions on Earth, with a possibility for real-time simulation or experiment on analogue sites.

The study proposes a proof-of-concept of deploying a swarm of pangolin-inspired robots to excavate these pits and the surface underneath, enabling rapid and efficient habitat construction. The design and capabilities of the swarm robots are outlined, emphasizing the scalability and flexibility of the swarm approach for habitat construction. The challenges and potential solutions for deploying and controlling a large number of miniaturized swarm robots in harsh lunar environments are also discussed, including robot design, communication and coordination strategies, and sensing and mapping techniques. The technical aspects of implementing swarm robotics are crucial for sustainable lunar exploration and settlement.

Overall, this paper presents a promising avenue for using cutting-edge robotics technology, inspired by nature, to revolutionize lunar exploration and habitation, enabling long-term human presence on the Moon and expanding the frontiers of scientific exploration and commercial development.