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DESIGN AND FEASIBILITY STUDY OF A DEPLOYABLE SNAKE-INSPIRED RESCUE SYSTEM FOR LUNAR EXTRAVEHICULAR ACTIVITY

Abstract

As future lunar missions like the Artemis missions to the Lunar South Pole, move closer to reality, the challenge of ensuring astronaut safety during Extravehicular Activities becomes critical. One of the most concerns is the ability to effectively rescue an incapacitated astronaut in the rugged and thermally extreme lunar environment. Conventional mobility aids, such as rovers, are bulky and not suited for quick deployment in emergency situations. This research presents a novel, deployable rescue system, inspired by the flexible and adaptive movement of snake-like organisms, designed to navigate the Moon's rough terrain efficiently, without the need for a rover.

This system have a unique kinematic motion mechanism that allows it to traverse diverse lunar landscapes, such as slopes up to 20 degrees, crater rims, and loose regolith. Unlike traditional wheeled or tracked mobility solutions, this system incorporates a dynamic digging action and an integrated steering mechanism, The proposed rescue device is lightweight, portable, and deployable by a single astronaut, making it a valuable addition to the limited resources and space available on lunar missions.

Key contributions of this work include a thorough mechanical and thermal design that ensures the system can operate in extreme lunar conditions. The design leverages advanced materials that minimize thermal expansion and withstand the harsh temperature swings on the Moon, ranging from -250C to +120C. Additionally, the system's kinematic motion is modeled using multi-body dynamics to ensure optimal traction and stability on low-gravity terrain, effectively validating its performance under simulated lunar conditions.

The system is designed for compatibility with the AxEMU spacesuit, ensuring that astronauts can operate it with ease, even in restrictive environments. Weighing less than 23 kg, the system offers a compact, energy-efficient, and rapidly deployable solution to rescue scenarios. This research addresses both the mechanical and thermal challenges associated with lunar rescue operations, demonstrating the feasibility of a system that significantly reduces infrastructure needs compared to traditional approaches.

In conclusion, this paper presents a preliminary design for an innovative lunar rescue system, showcasing its potential to enhance astronaut safety during lunar EVAs. The system's design incorporates detailed structural analysis, motion validation, and thermal modeling, with the aim of increasing its Technology Readiness Level (TRL) and making it a practical tool for future lunar exploration.