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CONCEPT STUDY OF A SMALL-SCALE DYNAMIC LEGGED ROBOT FOR LUNAR EXPLORATION

Abstract

The recent advancements in lunar exploration, driven by initiatives such as the Artemis project or the European Large Logistics Lander (EL3), call for robotic technologies to explore scientific targets, scout for resources, and prepare for a sustainable, long-term human presence on the Moon. However, many high-reward targets, such as the craters at the Lunar South Pole or the Aristarchus Plateau, lie in hard-to-reach areas due to steep slopes, crater rims, and unstructured terrain. Therefore, such high-risk high-reward targets are currently out of human and robotic reach.

Legged robots present a promising approach to exploring hard-to-access targets on the Moon. Legged robot prototypes have shown impressive locomotion capabilities in sloped, unstructured terrain in analog environments. However, despite their success in locomotion validation tests, we currently lack a target- and mission-specific analysis and design of the locomotion pattern, the thermal requirements, and the power system.

Legged robots, while having significantly matured over the last decade for terrestrial use cases, have not been deployed in space so far. With dropping launch costs and increasing accessibility to the lunar surface in mind, we have set our goal to develop a small-scale, legged, technology demonstration robot. In this paper, we present our conceptual work on such a robot, targeting a traverse distance of 200 m and a payload capability of 1.5 kg. We showcase a locomotion study to identify safe gaits and their respective power requirements on representative terrain. Based on the resulting mission profile, we model the heat emission and power requirements of the actuators and payloads. We model the environment, the robot, and the task schedule with sufficient accuracy to understand the thermal and power status of the robot during the mission. With the resulting model, we propose a preliminary design of the subsystems of our small-scale legged robot for lunar exploration. We consider this work an important step toward the deployment of legged robots on the Moon and, consequently, the exploration of hard-to-reach high-reward targets.