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TETHER MANAGEMENT AND DOCKING SYSTEM FOR MULTI-ROBOT RAPPELLING INTO
LUNAR LAVA TUBES

Abstract

Subsurface lava tubes have been detected from orbit on both the Moon and Mars. These natural voids are potentially the best place for long-term human habitations, because they offer shelter against radiation and meteorites. Skylights, formed by partial cave ceiling collapse, provide an entrance to several of the previously discovered lava tubes. Multi-robot collaboration may allow us to reach and explore these unknown cavities, where sending astronauts without prior knowledge is an evitable risk. This work presents the development and implementation of a novel Tether Management and Docking System (TMDS) designed to support the vertical rappel of a rover through a skylight into a lunar lava tube. The TMDS connects two rovers via a tether, enabling them to cooperate and communicate during such an operation. Its hardware comprises an active winch and two standard interfaces: a passive HOTDOCK and a passive EMI. Although particular robotic systems are used to demonstrate the feasibility of the task, the device can link any robot equipped with the active counterparts of these interfaces. The height of the TMDS platform is adjustable by two linear actuators in order to facilitate docking and transport. A robotic framework-independent software interface provides control over the platform height and the velocity at which the winch releases the tether. The winch speed is synchronized with the wheel speed of the rappelling rover, allowing for a controlled descent. The development of hardware and software components is part of the Cooperative Robots for Extreme Environments project. In January and February 2023, the approach was thoroughly tested in a three-week lunar analog mission on Lanzarote, Canary Islands. As a result, the collaborative multi-robot rappel into a lava tube was successfully showcased during the field tests. In summary, this work presents a solution for accessing lunar lava tubes with a heterogeneous team of rovers, and we share our lessons learned from the field tests by listing the benefits and shortcomings of the newly developed hardware.