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A COLLABORATIVE ROBOTIC SYSTEM FOR ENTERING AND MAPPING MARTIAN CAVES

Abstract

Martian caves represent prime locations for investigating evidence of extinct or extant life. In this paper, we propose a technology demonstration mission for Martian cave exploration using a heterogeneous robotic system. Heterogeneous systems are advantageous for Martian cave exploration due to their specialisation for specific tasks, flexibility, and adaptability to diverse conditions. Our mission focuses on the exploration of type 1 atypical pit crater caves in the Elysium Mons region due to their scientific value regarding the potential existence of life and ice water deposits. These caves, situated near the equator, offer low elevation and reduced radiation effects, ensuring safer landing conditions and high scientific outputs. Our mission considers the design of a robotic system capable of entering and mapping the cave environment under five work packages (System, Mission, Payload, Electrical and Mechanical). A risk

analysis, concept of operations and budget were established to make sure the requirements and objectives of the mission were fulfilled. To accomplish this mission, we have traded-off different rover locomotion concepts and selected a heterogeneous robotic system comprising a wheeled rover and a multi-rotor aerial robot in a parent-child configuration. The mission is defined in multiple phases starting with the traversal of the wheeled rover and the aerial robot from the landing site to the selected cave. Once at the cave entrance, the rover scans the circumference, and the aerial robot goes into the cave through the entrance to map it. The aerial robot will use a Simultaneous Localisation and Mapping (SLAM) algorithm along with a LIDAR to map and navigate the cave's interior. The wheeled rover (parent ship), powered by solar arrays, serves as a communication and recharging station at the cave entrance. Using a docking station, it will enable the aerial robot to recharge and communicate with Earth. The cave entry and mapping are demonstrated with a simulation to test the viability of the proposed approach. The proposed autonomy of the heterogeneous robotic system is demonstrated using simulation results in MATLAB Simulink.