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APPLICATION OF A HIERARCHICAL TASK PLANNER TO A LUNAR LAVA TUBE ANALOGUE ROBOTIC MISSION

Abstract

As missions grow more complex and daring, the concept of autonomous systems gains more importance. One of the most innovative missions is related to lunar lava tube exploration. Those volcanic architectures should be a natural shelter for the future manned mission in the equatorial sector of the Moon. Nevertheless, direct communication between Earth and the inside of the lava tube is difficult. Therefore, the robotic precursor exploration mission should be autonomous. The systems should move in an unknown environment, plan their tasks autonomously, decide the best course of action given their available resources, and communicate their results back to Earth. The aim of this study, conducted by Politecnico di Torino and ISAE-SUPAERO, is to define a structure that links operations, hierarchical task planning, path planning, localization and mapping to provide autonomous navigation capabilities for the lava tube exploration. The case study is a rover tested during the IGLUNA analogue mission, an ESA@LAB initiative at the Space innovation. The rover mission should explore an unknown environment reaching different targets. The rover is equipped with a LiDAR and two cameras, one for obstacle avoidance and one for mapping and localizing. The mission set-up will be similar to the one designed for exploring the lava tubes where a series of rovers and thruster-flying/hopping bots will join forces to provide information on their environment to a control centre. Therefore, during the analogue mission, the rover will be helped by a small drone, equipped with a tracking camera and LiDAR, capable of performing short flights of a few minutes to simulate the lunar bot. The systems will be in contact with a control centre far from the testing field. Moreover, the communication set-up will emulate a lunar one in bandwidth and communication delay. The tasks processed by the rover will be split between the two systems. The drone will provide a global map to the rover. This map will define the goals and provide their position with respect to the rover starting point. A hierarchical task planner would then acquire the list of goals and evaluate the best plan to reach them while monitoring both systems' available resources. It will monitor the mission execution, avoid obstacles, and the number path or plan re-evaluations. In this paper, the hierarchical task planner's performance and its integration with the mapping, path planning, and path execution modules will be presented.