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Author: Ms. Jasmine Rimani
Politecnico di Torino, Italy, jasmine.rimani@polito.it

Prof. Nicole Viola
Politecnico di Torino, Italy, nicole.viola@polito.it
Prof. Stéphanie Lizy-Destrez
Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), France,
Stephanie.LIZY-DESTREZ@isae-supaero.fr

A NOVEL APPROACH TO PLANETARY ROVER GUIDANCE, NAVIGATION AND CONTROL BASED ON THE ESTIMATION OF THE REMAINING USEFUL LIFE

Abstract

This decade will be remembered as the one in which humankind will be back on the lunar soil. Research centers, industries, and universities are showing a great interest in future missions toward the Moon. The establishment of a permanent human outpost and the exploitation of in-situ resources seems to be the main drivers of this new exploration era. However, on a more engineering wise point of view, the Moon can be the perfect testbed for autonomous operations and deep space exploration enabling technologies.

In this framework, the mission operations of a lunar rover are deeply linked to the performances of the guidance, navigation and control subsystem (GNC). Likewise, these performances are tied to the state of health of the system, measured by parameters like the battery level.

The study presented in this paper analyzes an adaptive and autonomous GNC system for a lunar rover. The GNC relays on the failure identification, isolation and recovery subsystem (FDIR) to estimate the available resources to autonomously plan a path. More in detail, the guidance node will choose the best path to visit a series of waypoints with different rewards based on their scientific return.

This new approach answer the needs of deep space exploration systems where the communication links are scarce and there is a need for autonomy and adaptability to unforeseen events. There is a shift of paradigm where the Earth's mission control leaves some decision-making tasks to the exploration system to primarily preserve the well-being of the mission. Thanks to the small-time delay with Earth, the Moon can be the perfect site to test and tune these new approaches.

Overall, the GNC will be composed of a navigation node, a guidance node, a resource estimation node, and a control node. The first node will simultaneously map and localize the rover in the lunar environment. The resource estimation node will continuously evaluate the remaining useful life (RUL) of the system. Moreover, it will continuously monitor the health parameters of the system. Eventually, the proposed algorithm will autonomously generate the best plan to maximize mission return while preserving the system's health and avoiding obstacles. The algorithm may decide to skip some low reward waypoints in order to preserve resources to reach more interesting sites. The key points of the proposed algorithm are the adaptability of unforeseen events and the onboard decision autonomy to optimize the path of the rover.