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Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

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AUTONOMOUS MULTI-MODE ROVER NAVIGATION FOR LONG-RANGE PLANETARY EXPLORATION USING ORBITAL AND LOCALLY PERCEIVED DATA

Abstract

This work is particularly relevant for future robotic exploration missions like Mars Sample Return. To fulfil its scientific objectives, these future missions require an advanced autonomy system capable of reaching different scientific interest sites in a short mission timeframe. To maximise scientific output, the next missions will need to cover more geographical area and minimise the time spent on traverses; hence one of the major challenge is to increase planetary rovers speed while increasing robustness to keep the rover safe at all times.

The planetary rover multi-mode navigation system presented here is designed to maximise the travel distance in function of the traversed terrain difficulty. The RG mode is selected autonomously in function of the terrain difficulty being traversed. This approach is inspired by the NASA rovers: using many different driving modes with various levels of functionalities depending on the surrounding terrain being observed, but selected by ground control.

This work is part of the European Robotic Goal-Oriented Autonomous Controller (ERGO) project funded by the European Commission H2020 Programme, which is developing building blocks of future autonomous space robotics missions providing more capabilities to meet extremely demanding mission goals. The building block in charge of navigation presented here is called "Rover Guidance (RG)" and is developed by Airbus Defence and Space Ltd. by building on the expertise from the ExoMars Rover Vehicle GNC system design.

The RG implements a new Navigation architecture using dynamically reconfigurable multi-mode autonomy together with a hazard prevention function checking for safety. This system adapts the amount of planning depending on the traversed terrain difficulty, performing more local planning for more challenging terrains. The RG uses the advantage of pre-processed orbital data, along with locally perceived digital elevation maps. The orbital data is segmented in tiles identifying the difficulty level, used both by the multi-mode Navigation and the long term Path Planner. Furthermore, the architecture presents the opportunity to combine navigation algorithms from different sources in order to seamlessly use the most appropriate one at specific moments of a mission.

The central focus of this paper is the description of this new architecture and the simulation runs performed in the high fidelity simulator inherited from the ExoMars Rover programme, demonstrating capability to traverse 1 km in a single Martian sol. Finally, enabling requirements for localisation, perception and software architecture will be discussed and the key influencing factors on distance traversed will be identified.