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Multi-scale Path planning for a Planetary Exploration Vehicle with Multiple Locomotion Modes

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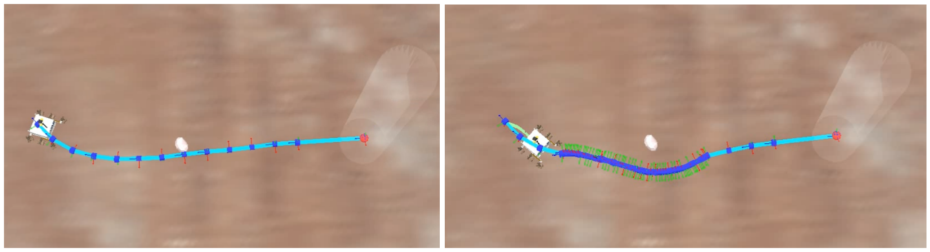
Extended Abstract

Planetary exploration vehicles (rovers) can encounter with a great variety of situations. Most of them are related to the terrain, which can cause the end of the mission if these vehicles are not able to traverse it. It was the case of *Spirit* rover, which got stuck in loose sand, making it impossible to continue advancing. A solution to this is to make rovers capable of modifying their locomotion to traverse terrains with particular terramechanic parameters. These rovers are classified as reconfigurable. An example of this kind of vehicle is the *ExoMars* rover. The particularity in its kinematic chain, with respect to other rovers, is the use of additional joints on top of each of its legs. Such joints are initially used to deploy the wheels once the rover has landed in Mars, but later, they can be used to improve traction on loose soil by the use of a locomotion mode called *wheel-walking*. In this sense, Azkarate et al. [1] performed some experiments using an *ExoMars* rover prototype that demonstrate this statement. To take the best out of reconfiguration capability on autonomy, an issue is yet to be solved: how to autonomously find the best path to reach a certain place taking into consideration a series of locomotion modes and different types of terrain.

Path planning is key to improve autonomy on rovers, i.e. it can help making them traverse more distance in the same time without depending on human intervention. This is useful for Martian exploration, where communications between rovers and ground stations occur only a few times per *sol* (Martian day). In this way, the number of places with scientific interest the rover can visit can be maximized. However, path planning in planetary exploration is not a trivial problem. The main reasons are the constrained computational resources and



(a) A path is initially computed (b) The path is repaired to avoid the obstacle

Figure 1: Example of proposed path planning working. Initially a path is computed using information about locomotion and terramechanics (a). Later, in this case it is repaired when the rover detects a little rock on its way (b)

the available information of the rover environment. Thus, following the way path planning operated in previous planetary exploration missions [2], in this paper a path planning solution that works with two scales of information is proposed. At a global scale, the algorithm makes use of information about terrain characteristics from external data sources such as satellite images. Moreover, in particular for this case, information relative to performance of each locomotion mode available in a reconfigurable rover. like *wheel-walking*, for different kinds of soil is considered as well. In this way, as result of executing path planning using global information, an optimal, smooth and continuous path is obtained. Fast Marching is employed, which consists on a numerical solver method already used in other path planning problems [3]. Besides, indication about which locomotion is better to be executed for each portion of path is also obtained. Then, since it is possible obstacles were not initially considered because of their size, path planning using local information obtained by the rover repairs the path in case any of them is on its way to efficiently avoid them.

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