SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 3 (3C)

Author: Mr. Alexandru Rusu
Centre National d'Etudes Spatiales (CNES), France, rusual@gmail.com

Ms. Sabine Moreno
Centre National d'Etudes Spatiales (CNES), France, sabine.moreno@cnes.fr
Ms. Yoko Watanabe
Office National d'Etudes et de Recherches Aérospatiales (ONERA), France, Yoko.Watanabe@onera.fr
Mr. Mathieu Rognant
Office National d'Etudes et de Recherches Aérospatiales (ONERA), France, Mathieu.Rognant@onera.fr
Mr. Michel Devy
LAAS-CNRS, France, michel.devy@laas.fr

STATE LATTICE GENERATION AND NONHOLONOMIC PATH PLANNING FOR A PLANETARY EXPLORATION ROVER

Abstract

ESA's Exomars mission will deploy a 300kg class rover on Mars, which is able to perform subsurface drilling, automatic sample collection and distribution to the on-board instruments for in-situ scientific measurements. Due to limited communication to Earth, the use of autonomous navigation in driving the rover towards a scientific target will increase the mission return by minimizing human intervention. This paper explores methods to improve onboard autonomous navigation capabilities of a planetary exploration rover, respecting mission-specific constraints such as energy consumption, memory-use and computation time. The recent Curiosity wheel failures emphasize the need of optimal path planning and execution in order to navigate in relatively risky but potentially more scientifically valuable environment. This paper proposes a global path planner using a multi-resolution representation for the navigation map which contains information on terrain difficulty with respect to locomotion capabilities of the rover. In the current navigation system developed at CNES, an optimal path planner runs on the local navigation map which keeps overwritten upon each new perception due to a limited onboard memory capacity. This local navigation map always has a non-navigable (and hence un-used in path planning) exterior band where the rover posability test cannot be applied. The proposed multi-resolution map utilizes these un-used cells to store low resolution navigability information over larger areas than the local map can cover. This allows to plan optimal paths over longer distance through complex obstacle configurations (dead-ends or canyons) with better knowledge on the surrounding heterogeneous terrain. This paper suggests four different path planning strategies using this multi-resolution navigation map, and their performances are analyzed through simulations in the CNES EDRES environment which emulates the ExoMars rover dynamics on Martian surface reconstructed from real data acquired by the HiRISE camera onboard NASA's Mars Reconnaissance Orbiter. It is shown that the memory-use and the computation time of those four path planning strategies are differently influenced by the obstacle configuration. Therefore, we propose an algorithm for automatic selection of the fastest path planner among the four depending on the terrain configuration. Finally, an architecture which integrates navigation maps of different precisions coming from resources other than onboard sensors is presented. The global multi-resolution map is built and updated by fusing high resolution navigation data acquired onboard with orbiter low resolution maps. Then a probabilistic path planner which takes into account the accuracy and credibility of the navigation information is used to calculate optimal tranjectories.