IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 2 (2B)

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TERRAIN BASED ANALYSIS, DESIGN, ASSESSMENT AND PLANNING TOOLBOX (TERRAIN-ADAPT) FOR A PLANETARY ROVER MISSION

Abstract

Any planetary landing and surface exploration mission must consider a variety of risks, including those inherent from the nature of the landing site chosen. Some of these risks can be mitigated by methodical planning and inclusion of metrics that can quantify the 'goodness' of the terrain for landing as well as surface mobility systems such as rovers. These metrics should also determine the compatibility of both the lander and rover systems' capabilities with the terrain. In this paper, we formulate methodologies and derive metrics to address two complementary problems related to the assessment of a terrain map for landing safety and rover-based exploration. The forward problem looks at evaluating terrain maps for suitability of landing and operating a rover within a given budget for a set of mission requirements. The inverse problem looks at defining rover system performance requirements to meet parametric objectives on a selected terrain. Towards these objectives, the Digital Terrain Model (DTM) of a landing site is first analyzed to evaluate landing safety w.r.t. hazards (crater, boulders, mountains, slopes and shadow regions), establish regions of communication line-of-sight between the lander and a rover (dependent on lander for earth communication), and provide destinations for rover traverse. Next, Global Path Planning and Analysis is used to determine if an optimal path for rover traverse to the destination is feasible from the given landing site, and if so, generate the paths and their characteristics like path length, path width, actual path profile etc. Analyzing the path characteristics over the terrain, help in characterizing the terrain distribution that the rover must operate on, and hence determine the broader operational requirements for the rover. Finally, Monte Carlo analysis of rover drive trials is used to determine the performance requirements of a navigation system (onboard and ground components) to traverse over a given terrain and conversely, assess the performance capability of a given rover system over a variety of terrain. The effect of various influencing factors – lander localization uncertainty, operational strategy, longitudinal slip etc. on rover performance are described. These methodologies are applied towards deriving navigation system requirements of the planetary rover over a sample lunar terrain map and assessing the sample lunar terrain map for landing and rover traversal. The corresponding results and analyses are presented in this paper.