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SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 1 (2A)

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AUTOMATED PLANNING TECHNOLOGY FOR THE CHANG'E MISSION

Abstract

In December of 2013, China successfully implemented another lunar exploration mission – Chang'e 3. One key task of this mission is to control the lunar rover via teleoperation. This control task is challenging in terms of the following requirements: (1) working in an uncertain environment; (2) continuous real-time interactions between the lunar rover and the environment; (3) evolving environment model built from real-time computer vision techniques; (4) frequent interactions among control centers and the lunar rover; and (5) dynamically generation of working plan (i.e., dynamic mission planning). In this paper, we report the mission planning techniques that enable our lunar rover to meet the above requirements. We present the modeling method for the mission and the corresponding automatic planning algorithm. Particularly, we show how our model captures the environmental constraints and capacity constraints of our lunar rover, as well as the real-time calculation requirements. These techniques fledged our lunar rover with the expected ability to achieve diverse scientific and engineering goals effectively while keeping itself in a safe working condition. Considering the dynamics and uncertainties underlying the mission, we proposed a hierarchical planning architecture consisting of an objective planning layer (high level), a mission planning layer (middle level), and a command planning layer (low level). Planning problems involved in each layer are different. Goals of the planning task in a lower level are projected from plans of a higher level. Our current modeling method combines the numeric temporal planning model from the AI planning community and our customized functions. The mission is expressed in Planning Domain Definition Language (PDDL). Our customized functions are in PDDL style syntax and evaluated online. AI planning helps us to decompose the mission planning problem into activities that correspond to different working modes of our lunar rover. For each activity, we use the action schema of PDDL to express constraints involving working temperature, energy, and other parameters. The resulted planning problem is solved by a temporal planning system that incorporates our online evaluation processes for functions. Experiments show that our proposed planning method is a valid solution.