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ROBUST PLAN EXECUTION STRATEGY WITH UNCERTAINTY FOR AUTONOMOUS ASTEROID PROBE

Abstract

The long flight distance of the asteroid probe leads to a high communication delay with the earth, and the space environment where the probe is located is dynamic and unpredictable. If the probe is remotely controlled by the commands from the ground station, it will not satisfy the requirements of real-time and robust. Autonomous mission planning and robust execution is the key technology to realize autonomous operation of asteroid probe. However, due to the uncertainty of the external environment and the execution effect of the probe's actions, the execution of the plan may fail. In order to deal with uncertainty, the autonomous system of the probe usually uses the replanning technology as a part of the execution. However, the replanning method is inefficient and cannot recover the system state in time. In order to deal more effectively with the uncertainty of the asteroid probe when executing its mission, this paper proposed a robust execution strategy of autonomous operation plan with uncertainty for asteroid probe. Firstly, the uncertainty in the execution process is analyzed, and a hierarchical plan execution model is established. Three types of actions are defined, including controllable, uncontrollable and monitoring actions, to describe and handle the uncertainty of the environment and probe system. Then, an execution monitoring mechanism based on continuous execution and dynamic adjustment is designed, the execution process is divided into two goals: mission achievement and execution monitoring, which are respectively reasoned and solved in different state spaces. For the mission achievement goal, the classical planning framework can be used to effectively calculate the mission plan before execution. For the execution monitoring goal, a reasoning method oriented by uncertainty dominance and plan allocability is proposed. In a dynamic execution process, after executing uncontrollable actions in each plan, the monitoring action plan is prepared to monitor the execution effect of the action, and the fault is recovered if necessary. Finally, experiments on domains about asteroid probe are run and the empirical results demonstrate the effectiveness and potential to improve the robustness of execution which guarantees the achievement of mission goals.