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ARC-CONSISTENCY TEMPORAL CONSTRAINT REASONING METHOD WITH UNCERTAINTY FOR LUNAR ROVERS' MISSION PLANNING

Abstract

Establishing an unmanned lunar research station is what most of the current world space powers vying for. However, due to communication limitations between the Earth and the Moon, using teleoperation at the Earth to control lunar rovers is inefficient. Therefore, it's urgent to study the autonomous operation technologies of lunar rovers during the construction process of lunar research stations. Among them, multi-agent mission planning technology is the key, which ensuring the achievement of the construction mission goal. However, the incomplete knowledge of lunar surface environment and the incomplete controllability of lunar rovers' actions have led to temporal uncertainty of actions during the lunar rovers' mission planning, posing challenges to mission planning techniques. For example, the duration of lunar rovers' movement is influenced by the roughness of lunar surface. In order to support the autonomous operation of lunar rovers, this paper focuses on the temporal constraint reasoning method with uncertainty for lunar rovers' mission planning. First, according to the mission characteristics of the lunar research station's construction, a mapping mechanism is established for the impact of uncertain factors on temporal constraints in lunar rovers' mission planning. In this mechanism, the uncertain factors are classified into external environmental uncertainty, self-behaviors' uncertainty and shared behaviors' uncertainty. And they are mapped into temporal network, which are categorized into three types of uncertainty in temporal intervals, including actions' range constraints, internal constraints and external constraints, as well as the increase and decrease of constraints due to temporal intervals' uncertainty. Next, a local dynamic maintenance strategy for temporal network with uncertainty is designed to handle various types of uncertain constraints. For the temporal constraints dynamically changed during the planning process, we analyzed their subordinate relationship with original network based on the constraints' type, in order to limit the propagation range of the constraints. In this way, only the affected constraints are processed, thereby reducing ineffective constraint reasonings. Then, by combining arc-consistency and dynamic controllability, an incremental arc-consistency temporal constraint reasoning method with uncertainty is proposed, which does not change the structure and constraints' weight of original temporal network, but changes the value range of each vertex, thereby quickly solving the controllability of uncertain temporal network and the minimum feasible interval of each controllable action. Finally, experiments on domains about lunar rovers' mission planning are run and results indicate our technology's effectiveness and rapidity in temporal reasoning with uncertainty, further guarantee the autonomous operation of lunar rovers.