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MODEL BASED MULTI-AGENT NUMERIC PLANNING SYSTEM FOR SPACECRAFT

Abstract

Planning for spacecraft is a complex problem, with diversity behaviors of heterogeneous systems of spacecraft and varied mission requests. Traditional space mission planners treat a spacecraft as a single entity. In fact, by taking each subsystem as an agent, one spacecraft is a loosely coupled multi-agent system, in which subsystems complete missions by cooperation. For such system, multi-agent planning method is more efficient. Also, there are durative actions and numeric variables in the problem, which raise numeric constraints like temporal and resource constraints. These factors make the planning for spacecraft a numeric planning problem, which is undecidable and not well studied in multi-agent planning problem. The aim of proposed system is to combine the efficiency of multi-agent planners and the numerical variable processing capacity of classic spacecraft planners. In this paper, we develop a model based multi-agent numeric planning system for spacecraft. A multi-agent numeric domain modeling language (MANDML) is used to express the knowledge of spacecraft and the mission requests with temporal and resources constraints, and these knowledge will be put in model files as input of the planner. This model based problem description makes the planner domain independent. We define privacy and public information for each agent, to preserve the privacy of agents and increase the communication efficiency. Instead of relying on a management agent to coordinate agents, we design a decentralized multi-agent planning architecture that allows agents to plan in parallel. In order to coordinate agents under the decentralized architecture, a dynamic agent interaction graph (DAIG) based on public information is proposed. We propose a novel multi-agent plan-space planning method. Plan process of each agent starts from an initial private partial plan, agents search for a complete plan by flaw resolution. When there are public flaws that an agent cannot resolute by itself, it will ask for help through DAIG. And numeric constraints handling algorithms based on multi-agent constraints network (MACN) are inserted into the planning process to propagate numeric constraints through agents. Finally, a comparison with a classic spacecraft planner EUROPA highlights the advantage of this system.