Paper ID: 19919
student

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (3) (5)

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AGENT BASED CONTROL FOR AUTONOMOUS COOPERATION OF INTELLIGENT SPACECRAFT CLUSTER

Abstract

Fractionated spacecraft cluster, which composed by different kinds of spacecrafts connecting with each other by self-organizing network and sharing a variety of resources, is a new development of distributed satellite systems. The characteristics of fractionated spacecraft cluster have the potential to enhance the adaptability and survivability of space capabilities. On the other hand, it's open architecture also brings some typical characteristics of complex systems, which leading to new challenges to the management and control problems of the fractionated spacecraft cluster. In order to adapt new problems caused by uncertain or unexpected events, the agent based control method on autonomous cooperative formation was studied as a start. First of all, control demands caused by complexity of the fractionated spacecraft cluster were analysed. According to these demands, each member of the fractionated spacecraft cluster was treated as an agent to found the whole system architecture, containing both orbital dynamics environment and the interactive informations transfer model. Then, taking graph theory as the description tool, control methods of autonomous cooperative formation, formed as behavior rules of each agent, were proposed. Based on interactive informations, those control methods totally use independent judgement determined by behavior rules to get formation reference and formation station of each spacecraft, and can achieve the autonomous cooperative formation goals without any fixed leader spacecraft. At the same time, collisions of spacecrafts can be avoided as well, because of the interactive informations transferred on self-organizing network. At last, the stability of these autonomous cooperative formation methods was analysed through Barbalat Theorem. Computational experiments were carried out as also, in both digital simulation system and hardware in-the-loop simulation system, to verify the effectiveness of these agent behavior rules. The digital simulation system is composed by computers simulating the whole agent based system architecture, while the hardware in-the-loop simulation system is composed by computers which simulate the orbital dynamics environment and agent behavior rules, and wireless communication hardwares which transfer real-time interactive informations. In those two simulation systems, the autonomous cooperative formation methods proposed above were proved to be effective, even considering some uncertain events, including new spacecraft join in or some working spacecrafts leave the fractionated spacecraft cluster system, and the real communication delay. Study results show that, fractionated spacecraft cluster has the potential to enhance its autonomous and intelligent capabilities. And the agent based control methods provide them a new approach.