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RELATIVE NAVIGATION AND CONTROL FOR FRACTIONATED SPACECRAFT BASED ON GRAPH THEORY

Abstract

Fractionated spacecraft has been well concerned in recent five years because of its unique technical merits. The concept of the fractionated spacecraft is to separate the traditional monolithic satellite into free-flying service modules and different payloads, which are connected by self-organizing network wirelessly. DARPA began a program called the System F6 (Future, Fast, Flexible, Fractionated, Free-Flying Spacecraft) in 2008. The new characteristics of fractionated spacecraft make the design of the Guidance, Navigation and Control system more challenging.

Fractionated spacecraft is different from formation flying satellites; fractionated spacecraft usually do not require the strict formation configuration, they just flight in proximity swarm, as long as they do not collide with each other and are within the communication range. First, the modules of the fractionated spacecraft are modeled as the graph nodes, becausethe modules cannotobtain all the information about the other modules, such as the large scale of the modules, the capability restriction of the modules, some function failures of the modules. We analysis the connectiveness and stability of the navigation graph; we use the span tree to describe the conditions of the navigation issue. Then, as to the control approach, we use the graph theory to design the control law of the fractionated spacecraft, the traditional leader-follower approach, behavior-based approach and virtual structure approach can be uniformed into the framework of graph theory. The formation can be described as a graph; the edge can represent the communication of the different modules. After modeling the fractionated spacecraft as a graph, the algebraic graph theory can be utilized to design the control strategy, analyze the stability and realize the formation transformation of the models.

In a word, considering the new characteristic of the fractionated spacecraft, we use the graph theory to study the navigation and control issue of the fractionated spacecraft. After modeling the spacecraft system as a graph, the relative navigation can be analyzed; furthermore, the control approach can also be designed. Graph theory is very suit for the navigation and control of large scale fractionated spacecraft.