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DISTRIBUTED CONTROL OF FRACTIONATED SPACECRAFT BASED ON CYCLIC PURSUIT STRATEGIES

Abstract

Fractionated spacecraft has been well concerned in recent five years because of its unique technical merits, such as increased reconfigurability and overall system robustness, which can in turn enhance the scientific return. 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. The new characteristics of fractionated spacecraft make the design of the Guidance, Navigation and Control system more challenging.

Cyclic pursuit strategy is a new decentralized control policy. The pursuit framework is particularly simple in that, for n agents, agent i simply pursuits agent $i+1$ modulo n. This paper presents cyclic pursuit strategies with different pursuit angles, which differ from conventional pursuit methods, and lead to more flexible control parameter design and various coordination motions. Firstly, the relative translational dynamics and collision free close proximity free flying configurations are proposed, which make the free flying of fractionated spacecraft as stable as possible. Secondly, three-dimensional finite-time cyclic pursuit algorithms with different pursuit angles are put forward for both single-integrator kinematics and double-integrator dynamics, which guarantee the convergence of tracking errors in finite time rather than in the asymptotic sense. The relationship between the eigenvalues and the pursuit angles are investigated, and several symmetric formations are obtained, including rendezvous, evenly spaced circular formations, and Archimedes spirals formations. Then, we extend the general fixed directed communication topology to the dynamic directed communication topology, which is more robust to environment disturbances. Finally, the re-gathering and scattering maneuver and formation reconfiguration missions are simulated, which demonstrate that the cyclic pursuit algorithms can meet the formation control of fractionated spacecraft in various patterns.

This paper investigates the cyclic pursuit control approach for fractionated spacecraft. Compared with the traditional methods, such as the leader/follower method, the virtual structure method, the behavior based method, the distance, bearing, or relative position based method, the cyclic pursuit approach only requires local information from neighbor spacecraft, by interacting with only a few neighbors, the coordination control of fractionated spacecraft is autonomous, flexible, and scalable, when the group size changes, the cyclic pursuit strategy is kept the same.