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Space Robot Active Collision Avoidance Maneuver Under thruster failure

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Abstract:

The problem of robust control for space robot collision avoidance maneuver under constant thrust is studied in this paper. Firstly, based on the Clohessy-Wiltshire (C-W) equations and by considering uncertainties and thruster failure in radial direction, the dynamic model for space robot is proposed. Then, based on the established model, a parametric design method of robust controller is given by using the eigenstructure assignment theory and the model reference theory. Next, a new constant thrust switching algorithm is proposed by using the impulse compensation method. Finally, simulation results and performance analysis validate the effectiveness of the proposed approach.

Keywords: Space robot; Collision avoidance maneuver; Constant thrust; Thruster failure.

I. Introduction

With advances in space applications, space robot can perform various tasks such as building/operation of the international space station (inspection, logistic support, rescue from orbit, etc.), lunar/planetary explorations. Because extravehicular activities of astronauts are very expensive and dangerous in practice, it is better to assemble the large space structures via a coordinated team of autonomous space robots. However, the development of such robotic systems creates a number of technical challenges, including those in the dynamics modeling, path planning and collision avoidance[1]-[6].

The exploitation of the near-Earth space environment by commercial, military, and scientific interests during the last 50 years has led to the increasing likelihood of collisions between orbiting objects. Because their positions are not known to extremely high precision, the inevitable question of collision possibility becomes one of great interest[7]-[10].During the last few decades, the problem of spacecraft collision avoidance maneuver has attracted considerable attention and many results have been reported[11]-[20]. Among them, two major kinds are rule-based approaches and optimization-based approaches. The rule-based approaches include the avoidance strategies of using collision avoidance probabilities [11]-[14], the artificial potential field based approaches[15], etc. Compared with other rule-based approaches,the avoidance force from artificial potential field based method is usually available in analytic and continuous form[16]. In the optimization-based approaches[17]-[20], the collision avoidance is achieved by adding corresponding constraint conditions and an optimized solution is obtained.

Motivated by the above discussions, in this paper we study controller design problem for space robot collision avoidance maneuver with parameter uncertainties and thruster failure in radial direction. Based on the Clohessy-Wiltshire (C-W) equations, the collision avoidance models are established by using coupling effects under thruster failure. On the basis of our previous research[21][22], a more simple and effective criterion for judging collision possibility is proposed. Then, a robust controller under the theoretical continuous thrust is designed based on the theory of reference model tracking which effectively solve the finite-time stabilization problem. Next, a more accurate constant thrust fitting algorithm which include more detailed classification is proposed by using the impulse compensation method. At last, an illustrative example is provided to show the effectiveness and advantage of the proposed control design method.