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IMPULSIVE CONTROL STRATEGY FOR FORMATION FLIGHT IN THE VICINITY OF THE LIBRATION POINTS

Abstract

In recent decades, space-based observatories and interferometry missions (e.g. TPF, MAXIM, etc.) have aroused great interest in formation flight near the vicinity of the libration points in three-body regime. Due to sensitivity of trajectories near the libration points, continuous control is necessary to precisely maintain formation flight. However, the science goals of deep space missions may impose a series of constraints that eliminate continuous control as a feasible option. In such scenarios, an impulsive control strategy may represent an important capability.

Among all the discrete control approaches, the most practical may be the targeting approach that introduced by Howell and Barden. The nominal path of the deputy spacecraft is divided into segments of a given time. At the beginning of each segment, an impulsive maneuver is implemented that targets the nominal state at the end of the segment. This method is referred to as equi-time targeting method (ETM) in this paper. Because the time span between successive maneuvers is treated as a constant, some trajectory segments are significantly below the predetermined error bound. Therefore, it is possible to further exploit the error bound so that the time span of these segments could be increased and the number of maneuvers could be decreased.

In the present investigation, two specific tasks are accomplished for the purpose of improving the ETM. First, tangent targeting method (TTM) is developed to fully exploit the error bound. This method is essentially a two-level differential corrector. On each segment, the Level I differential corrector produces a maneuver which helps to meet end-position constraint, while the Level II differential corrector adjusts the end time of the segment to make sure the trajectory segment is tangent to the error bound. Then, a comparison between TTM and ETM is carried out. The second task is the proposal of a formation keeping strategy based on TTM and probability theory to handle uncertainty introduced by thrust implementation error. Monte Carlo analysis is presented to test this strategy.

Numerically implemented comparison reveals the competitive advantages of TTM over ETM. By utilizing TTM, the number of maneuvers can be significantly decreased and the length of time between successive maneuvers is increased by more than 50% on average. Monte Carlo simulations including 100 trials demonstrate that, the TTM-based keeping strategy can be successfully applied to maintain formation configurations near the vicinity of the Sun-Earth L2 point under the existence of thrust implementation error.