Paper ID: 13617
oral
student

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (1) (1)

Author: Dr. Rui Qi
Beijing University of Aeronautics and Astronautics (BUAA), China, treymackey@163.com

Prof. Xu Shijie
Beijing University of Aeronautics and Astronautics (BUAA), China, starshijiexu@gmail.com

CONTROL OF ORIENTATION FOR SPACECRAFT FORMATIONS NEAR THE SUN-EARTH L2 LIBRATION POINT

Abstract

Spacecraft formation flying is an evolving technology that represents a concept of distributing the functionality of a single, large, virtual instrument between several close-flying satellites. Recently, formation flight near the Sun-Earth L2 libration point has been proposed to take advantage of the observational potential of extra-solar planets from this region, and has increasingly attracted the interest of both engineers and scientists.

Although formation flying missions often benefit from valuable operational features of libration point orbits, they also suffer from the inherent instability of these trajectories. Therefore, a control strategy is required. In previous work, we have developed “tangent targeting method (TTM)” to improve the targeting method introduced by Howell and Barden, with emphasis placed on the control of relative separation between the chief spacecraft and the deputy. However, for formation flying such as space-based observatory, the precise control of chief-deputy line is more important than the precise control of vehicle separation. Therefore, the orientation issues need to be addressed.

In the present investigation, the TTM is reformulated to control the chief/deputy architecture to maintain a prespecified orientation. On each trajectory segment, the error curve of the relative orientation angle is controlled to be tangent to the predetermined error bound by employing a two-level differential correction. The Level I differential correction produces a maneuver which helps to meet end-state constraint, while the Level II correction adjusts end time to satisfy the tangent condition which guarantees the maximization of maneuver intervals. In order to investigate the practical convergence of the TTM, “critical error corridor radius” and “critical time interval”, playing the role of analogues of radius of convergence, are defined to characterize the domain of convergence of TTM from different points of view.

Numerical results are presented for Micro-Arcsecond X-ray Imaging Mission (MAXIM). The nominal vehicle separation is set to 500 km, and the chief-deputy line requires a pointing accuracy of 10 arcseconds. Generally, about 1.16 days of no-control for science observation is required. By employing the TTM, the average length of time between successive maneuvers is increased to 2.05 days. Particularly, the minimum maneuver interval is 1.50 days, and it satisfies the observation requirement of space-based observatory. Variation of parameter studies are conducted, indicating that the critical error corridor radius and the critical time interval are independent of formation size. Simulations show that the TTM has very strong convergence properties, and therefore has very wide applicability.