

66th International Astronautical Congress 2015

ASTRODYNAMICS SYMPOSIUM (C1)  
Guidance, Navigation & Control (2) (8)

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DESIGN OF SLIDING MODE CONTROLLERS FOR FORMATION FLYING ALONG UNSTABLE  
PERIODIC ORBITS IN CR3BP

**Abstract**

Recently formation flying along halo orbits near a libration point or simply formation flying in the vicinity of a libration point of the circular-restricted three-body problem (CR3BP) has been studied from the point of view of future missions such as spacecraft imaging arrays. In the former case, the linearized equations of motion along a halo orbit is used, but their coefficients are periodic functions and only numerically available. Therefore, implementation of stabilizing control is also numerically available and it is difficult to obtain fuel-efficient controller.

In our previous paper, we proposed a simple method to generate and stabilize quasi-periodic orbits near the libration points in CR3BP. For this purpose, equations of motion in the CR3BP were normalized by the distance between the two primary bodies and transformed to the modal form. Control input was determined in the modal domain to stabilize the unstable mode.

In this paper, we derive the various sliding mode controllers (SMC) to achieve robust fuel-efficient stable periodic motion as the same spirit of our previous study. The first one is to employ the conventional SMC. Since the conventional SMC utilizes a discontinuous switching function, a significant flaw called chattering can occur. Chattering is an inevitable phenomenon which can consume a lot of energy, cause mechanical wear and deteriorate the system's performance. In the second approach, the chattering attenuation SMC is designed to mitigate the chattering effect over time. In the last approach, a continuous SMC is employed based upon a new Lyapunov function to smooth the control input. Furthermore, a trade-off between the formation-keeping accuracy and the robustness against disturbances are studied in detail based on three types of SMC controllers by revealing some important design parameters for these approaches. We also take the size and frequency of the periodic orbit as parameters and compute  $\Delta V$  to maintain these orbits. Our approach permits designing and maintaining periodic orbits near the libration points which are more flexible for space missions than natural orbits. Finally we apply our controllers to formation flying along a halo orbit and compute  $\Delta V$  to maintain quasi-periodic orbits along it.