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STATION KEEPING AND FORMATION FLYING OF REFLECTIVITY CONTROL SOLAR SAILS AT SUN-EARTH L2 POINT BY ARTIFICIAL EQUILIBRIUM POINT APPROACH

Abstract

Stabilization of spacecraft's orbit around Lagrange points has studied by many researchers because of its usefulness for future space missions. Among them, the Sun-Earth L2 point (SEL2) has advantages of the easiness of spacecraft thermal control and lowness of orbital transfer energy, therefore it is especially important to study station keeping strategy around this point. This study investigates station keeping and formation flying design of solar sails around the Sun-Earth L2 point (SEL2) by means of a new method of creating artificial equilibrium points (AEP) and periodic orbits around these points.This study aims to provide a novel and practical solution to the fuel free solar sail station keeping and formation flying at SEL2. Previous studies of the solar sail station keeping have done under the assumption that the solar sail produces constant acceleration. In this work, we focus on reflectivity control devices (RCD) as actuators utilizing solar radiation pressure. In spite of not using propellant, the reflectivity control solar sail can achieve variable low-thrust continuous acceleration. The new AEP method can take into account variable acceleration positively. With this method, new equilibrium points which have new features of force fields can be generated. The method introduces the artificial potential and the artificial momentum that are included in the acceleration input which is shown in the equation (1) where $\mathbf{a_{input}}$ is the acceleration input, $\mathbf{r}$ is the position vector, $\phi(\mathbf{r})$ is the artificial potential, $\mathbf{v}$ is the velocity vector, and $A(\mathbf{r})$ is the artificial momentum.The functional form of the artificial potential affects the feature of the force field around the spacecraft, and that of the artificial momentum determines the periodic orbits' form and frequency.By selecting the artificial potential appropriately, we design new equilibrium points in the vicinity of SEL2 which are suitable for solar sails in terms of the magnitude and the direction of the required acceleration vector. Formation flying of multiple solar sails is to be designed using the method. In addition, RCD control strategy is also being investigated. The thrust acted on a solar sail varies by the change of the optical reflectivity feature, and the reflectivity feature also changes the solar sail attitude.Therefore, both orbit and attitude should be controlled by only RCDs. We confirm the feasibility of designed orbits of reflectivity control solar sails.

$$\mathbf{a_{input}} = -\nabla\phi(\mathbf{r}) + \mathbf{v} \times A(\mathbf{r}) \tag{1}$$