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ATTITUDE AND ORBIT CONTROL FOR SOLAR SAIL BASED ON REFLECTANCE MODULATION

Abstract

Solar sail spacecraft is a vehicle which uses the pressure of sunlight to achieve implementation of spacecraft propulsion. Due to the use of natural solar energy rather than chemical fuel, solar sail spacecraft could fly to deeper space with more loads. In most published literature, attitude dynamics is often discussed separately from orbit dynamics, while the orbit change directly caused by the force change incurred by the reflectivity modulation is mostly neglected. However, Owing to the sail orbit control and attitude control's coupling phenomenon, this paper considers using attitude control for trajectory control.

First of all, this paper builds the solar sail spacecraft's dynamics model. Assume that the solar sail considered here is a spinning disk sail. The diffuse reflection modulation model's capabilities for torque and force generation are discussed. Reflectivity modulation device are applied to the edges of the membrane. Each liquid crystal tile's reflection changes with the change of voltage, such that the induced force on each small element's surface is changed, generating a torque eventually. Then, the transitive relation between voltage with moment is deduced. The fit curve equation could be attained by analyzing previous study results. We plug it into spacecraft's dynamics model so that we can obtain the transitive relation. Third, this paper researches the influence of the moment generated by the change of distance from a certain area of liquid crystal tiles to the solar sail's centre, and also the paper optimizes liquid crystal tiles' location and geometry size of LCD tablet in order to consume least electric energy. This section mainly performs simulation in order to find the best design solution.

This paper discusses an extensive use of the reflectivity modulation technology and proposes a joint orbit and attitude control method for solar sail. This method can be used as a stand-alone orbit and attitude controller for some applications, and it can also serve as a complement to other orbit and attitude control mechanisms to enhance performance and save fuel consumption.