Paper ID: 79942
student

51st IAF STUDENT CONFERENCE (E2)
Student Conference - Part 2 (2)

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SPACECRAFT ORBITAL AND ATTITUDE CONTROL AROUND AN ASTEROID SUBJECTED TO UNDERACTUATED CONDITIONS

Abstract

In recent years, near-earth asteroids and comets (such as Apophis, Eros, Ida, and Bennu) have attracted much attention to research areas due to their relation to the time when the solar system was formed. For the exploration of asteroids, several research projects and missions have also been proposed. Most of these studies have either been done on the attitude motion of spacecraft or the orbital motion of spacecraft around the asteroid, assuming it to be a point mass. However, much attention is still needed toward the coupling between attitude and orbital motion while treating the spacecraft as a rigid body. As in actual missions, attitude and translational motions are generally coupled because it is crucial to maintain the desired attitude while maintaining the spacecraft's desired position. Additionally, near the asteroid, its gravity field, which would be non-spherical due to its irregular shape and non-uniform mass distribution, cannot be ignored. This paper demonstrates the study for designing simple control laws for a spacecraft's coupled orbital and attitude motion over an irregularly shaped rotating asteroid with uncertain parameters. The study presents an idea for a high maneuvering actuator configuration for a spacecraft equipped with a VSCMG, a reaction wheel, and a single-body-fixed electric thruster. Since a single-body fixed thruster cannot have complete position control, the problem is under-actuated. It is a coupled problem that provides high maneuverability with full attitude control and underactuated position control using minimal actuators. A stable PD control law is developed for orbital control, while nonlinear sliding mode control with Quaternion is used to develop the attitude control law. Since it is an underactuated problem, we use the time separation technique between position and attitude control. The closed-loop stability of the system is analyzed and proven using Lyapunov stability criteria. Control of the spacecraft for the closed orbit and hovering over the asteroid is performed using the proposed design. Simulations and results are carried out for Ida and 433 Eros asteroids with the required control parameters.