Paper ID: 58450
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student

18th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Post Mission Disposal and Space Debris Removal (1) (5)

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ESTIMATION OF ANGULAR MOMENTUM USING ARTIFICIAL MARKERS FOR THE CAPTURE OF NON-COOPERATIVE SPACE DEBRIS TARGETS

Abstract

As the number of Earth-orbiting satellites continues to steadily increase, so too does the risk of space debris posing a significant threat to future near-Earth space activities. The removal of space debris from orbit is one of the definitive solutions to this issue. To achieve active removal of space debris, accurate estimation of the state of motion of the target is crucial. In addition to that, a safe approach is preferable. Many strategies have been proposed for estimation of motion of a non-cooperative target, but there are still problems with regards to conducting precise, robust and cost-effective estimation in real-time. This study proposes a new strategy to solve this issue - a real-time, robust and practical method based on optical navigation around small bodies.

The strategy starts with putting artificial markers on the surface of the satellite before launch. Then, relative positions of the target to markers are estimated using geometrical relationships of the markers. This estimation method is based on the technique to approximate the relative position to a target asteroid, as used by spacecraft, like JAXA's Hayabusa2 spacecraft. Finally, a chaser approaches the target from the direction of the angular momentum vector, allowing a chaser to synchronize its rotation with the spin of the target and minimize the risk of uncontrolled capture. In general, the moment of inertia of the target is assumed to be known, however it is considered as an estimating parameter for cases where the target may be fragmented. The estimation is conducted by using the fixed geometric relationships of the markers' positions in an image and in a three-dimensional frame. Since the relationships between markers are known, parameters of motion can be calculated by reconstructing positions from the images considering camera geometry and dynamics of the target. As this method includes only the process of solving kinematic equations, the parameters of motion can be obtained instantly.The validity and effectiveness of this proposed method is demonstrated using numerical simulations.

The simulation results verify that the proposed method can estimate the state of motion of the target precisely and rapidly as compared to other estimation methods, and that an approach from the direction of angular momentum sufficiently minimizes the risk of uncontrolled capture. These results confirm that the proposed method is a viable, robust option for use in the capture and future removal of non-cooperative space debris targets.