14TH IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Space Debris Removal Concepts (6)

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DESIGNING MULTIPLE SPACE DEBRIS REMOVAL MISSIONS CONSIDERING FUEL EFFICIENCY AND ENVIRONMENTAL REMEDIATION

Abstract

A great growth of space debris is an important issue for the long-term sustainability of outer space activities. Today, there are more than 17,000 debris on the Earth orbits which are cataloged, and they are orbiting at a high speed of approximately 7km/s in Low Earth Orbits (LEO). Because of their orbital velocity, a piece of space debris breaks into a large number of new debris when it collides with other spacecraft on orbit. Therefore, Space Debris Removal is a very important measure to be taken for a future secure and safe space development. Active Debris Removal (ADR) is a way to remove large, massive and intact objects by using debris removal spacecraft. Several studies have carried out to achieve ADR missions and most of them focused on optimization of orbital transfer. This study aims to design ADR spacecraft's orbit from the perspective of fuel efficiency and environmental remediation, i.e. this study tries to design the orbit by minimizing velocity inclement for orbital transfer and maximizing the removal effectiveness. This study concerns the following ADR scenario. An ADR spacecraft rendezvouses with a debris in the Sun-Synchronous Orbits and captures it. The removal spacecraft attaches a deorbit device to the target debris. After releasing the debris, the removal spacecraft performs maneuvers away to approach another target debris. This study includes the debris removal process as a coasting time for simplicity. Then, this study aims to remove three different debris. Three targets debris are chosen from six candidates randomly and order of rendezvous, coasting time and transfer time are also given randomly. In order to solve this multiple rendezvous problem, several variables such like, a combination of rendezvous, coasting time and transfer time are needed to be determined. Since this study treats combinational optimization problem, the number of feasible solution becomes enormous. In order to find an optimal solution efficiently, Genetic Algorithms (GA) are used. This study aims to design trajectories by optimizing two factors. To solve a multiple-objective optimization problem, this study adopted a random weighted-sum method. Since this method gives GA a tendency to search multiple search directions, GA can sample throughout solution area equally. The removal effectiveness is evaluated by accounting for possible fragments from each target in the near future, which is projected by a space debris evolutionary model.