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Author: Mr. Zhehao Xing
Beijing Institude of technology, China

Prof. Zixuan Liang
Beijing Institute of Technology, China
Mr. Hao Zeng
Beijing Institute of Spacecraft System Engineering, China Academy of Space Technology, China

RE-IMPACT GUIDANCE FOR ASTEROID DEFENSE CONSIDERING MULTI-DEBRIS AVOIDANCE

Abstract

The collision of a Near-Earth Asteroid (NEA) and the Earth would cause severe disaster, which is a long-term threat to humans. Destroy the asteroid or change its orbit by a hypervelocity impactor is an effective and feasible mean of asteroid defense. Studies have shown that the asteroid usually has a rubble-pile structure, meaning that it would be partially destroyed and produce numerous debris after the impact. As the partially destroyed asteroid may still pose a threat to the Earth, a re-impact is required. The re-impact against the asteroid needs to consider the debris as obstacles, which faces the following difficulties. First, the debris obstacles are numerous and widely distributed, posing a great threat to the impactor's safety; Second, the impactor moves extremely fast, leaving less time to perform maneuvers for obstacle avoidance. Therefore, to achieve a successful re-impact against the asteroid, it is necessary to develop an advanced guidance method that has the capability to avoidance numerously obstacles with high relative speed.

In this paper, an obstacle avoidance guidance method based on sequential B-planes is proposed for the re-impact against an asteroid with multiple debris nearby. Firstly, a series of derived B-planes are arranged from the traditional B-plane to the initial position of the impactor according to the distribution of the debris obstacles. In the flight of approaching the asteroid, the corresponding B-plane and a small number of debris are considered, which would help to reduce the burden of obstacle avoidance. Then, focusing on the short obstacle avoidance time, a constraint-guided predictor-corrector method is designed. The constraints of impactor state are established based on the distribution of debris obstacles and the derived B-planes. Based on the constraints, an analytical guidance law is used to predict and correct the lateral maneuver trajectory of the impactor, so that the impactor can avoid beforehand the debris obstacles that may collide with. Finally, the proposed guidance method is simulated in a re-impact against an asteroid. The results show that the hypervelocity impactor using the guidance method can avoid the debris obstacles and impact the target accurately.