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Terminal guidance of small body impact using velocity increment corridor

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With NASA's DART mission being around the corner years after the Deep Impact mission implemented successfully, the kinetic impact scheme has become one of the main ideas in the defense of hazard near-Earth small bodies. Due to the limitation of human's carrying capacity, the kinetic impactor useable at present has a relatively small mass which cannot generate enough kinetic energy during the impact, resulting in a weak influence on the orbit state of the hazard small body. A guided impact scheme which uses a captured small body as the kinetic impactor has been proposed recently. The method is supposed to significantly increase the impact kinetic energy, enhancing the impact effect in future small body defense missions.

In the terminal guidance stage of small body high-speed impact missions, the method of predictor-corrector is generally used which can achieve high accuracy hits by providing a series of pulse thrusts before collision. However, in the guided impact scheme, the impactor carrying a small celestial body has an enormous mass and insufficient control capability. The velocity increment that can be provided by pulse correction within a few hours of the terminal guidance phase is very limited. It's hard for the traditional predictor-corrector guidance method to achieve high impact accuracy when targeting at a small body with a diameter of 100 meters or less, since the number of the orbit correcting maneuvers and the maneuvering time are both fixed. In this paper, the influence of the quality and volume of the

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impactor on the impact accuracy is firstly studied under a given upper limit of thrust. A calculation method for the largest mass of the captured small body is proposed. In order to solve the problem of insufficient accuracy of traditional guidance law, a velocity increment corridor model is proposed. Then a new guidance method which can adaptively adjust the timing and number of impulse maneuvers is designed on the basis of the model. The new method is able to maintain the impactor's flight state deviation within the correctable range, thereby reducing the impact miss distance and improving the hit rate. Finally, a Monte Carlo simulation of high-speed impact terminal guidance is carried out. The result shows that compared with the existing methods, the newly proposed guidance method based on the velocity increment corridor has higher impact accuracy, which can provide a theoretical reference for future kinetic impact missions.