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Design of trajectories for asteroid impact in the Earth-moon system using the pseudostate theory

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ABSTRACT

Abundant studies on heliocentric trajectories of asteroid impact have been conducted. The trajectories can be classified into different types based on the used propulsion, such as impulsive trajectories, low-thrust trajectories and solar-sail trajectories. The planets' gravity assists have been analyzed and employed to improve the relative momentum at the time of asteroid impact. The optimization methods include direct and indirect methods have been investigated as well.

With a designed heliocentric trajectory, impact usually takes at several months or even years in advance of the asteroids' close approach to the Earth. However, the orbital elements and physical parameters of a potential hazard asteroid have uncertainties. Because of these uncertainties, the use of heliocentric impact trajectories may lead to failure of impact or reduce the effect of deflection. More importantly, there might be some potential hazard asteroids which are identified just

several weeks or days before its close approach to the Earth. Because of the short warning time, the heliocentric trajectories cannot be applied to impact the asteroid. Therefore, design of trajectories for asteroid impact in the Earth-moon system is investigated in this paper.

This paper presents a new method in which the pseudostate theory is used to provide a fast approach for designing impact trajectories in the Earth-moon system. The pseudostate theory is regarded as an approximate closed-form of the Lambert solution to three body problems. In this theory, over lapped conics are used instead of the three body model such that the trajectory integrations can be analytically solved. In our method, the patched conic method is combined with the particle swarm optimization method for preliminary designing of optimal impact trajectories with a lunar gravity assist. In the optimization, the launch time, the flyby time, the impact time and the flyby angles are taken as optimization variables. The impact momentum is taken as the performance index. The pseudostate theory is used as an intermediate step from the patched conic solution to the restricted three body solution. Derivations and numerical simulations for validating our method will be presented in the final paper. Analysis of the asteroid’s relative position to the moon and its velocity on the impact momentum will also be conducted.

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