IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (2) (5)

Author: Dr. Kohei Yamaguchi
Nagoya University, Japan

Dr. Takaya Inamori
Nagoya University, Japan
Dr. Kikuko Miyata
Meijo University, Japan
Mr. Xinbo Gu
Nagoya University, Japan

EFFECTIVE TRAJECTORY OPTIMIZATION METHOD FOR KINETIC IMPACTOR FOR ASTEROID DEFLECTION MISSIONS

Abstract

The risk posed by Earth threatening asteroids has been studied, and several methods to mitigate the risk have been proposed. The kinetic impactor (KI) is a spacecraft that impact against an asteroid to deflect it from Earth collision route. Though the KI is one of the potential methods, the feasibility of the KI mission depends on the spacecraft relative impact velocity. Generally, larger relative impact velocity yields larger deflection distance and makes the terminal guidance phase to achieve spacecraft impact difficult. To address this problem, we propose a trajectory optimization method that increases not the relative impact velocity but the achievable change in the orbital energy of the asteroid. The change in the energy is proportional to the inner product of the heliocentric asteroid velocity vector and spacecraft relative impact velocity vector at an impact point. The inner product is called as the impact geometry. In the previous work, we proposed the impact-geometry map (IGM) that visualizes the achievable change in the impact geometry caused by a KI mission as a function of the orbital shape of the spacecraft. By using IGM, in this paper, we propose a trajectory optimization method that increases the deflection distance by not increasing the relative impact velocity but increasing the impact geometry. First, we derived locally optimal thrust control law that maximizes the change in the impact geometry. Simulation results showed that the proposed control law achieves a monotonic increase in the impact geometry. Since the locally optimal control law determines the thrust direction based on the shape of the asteroid orbit and does not care the terminal position of the spacecraft and the asteroid, the trajectories are numerically optimized to achieve the impact against the asteroid. The optimization scheme is tested for fictional asteroid deflection scenarios created from actual near-Earth asteroids. The results showed that the proposed method achieves larger deflection distance compared with previous trajectory optimization method. Besides, it is more important, it can decrease the relative impact velocity in spite that the deflection distance was extended.