 Paper ID: 78095
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (1) (3)

Author: Ms. Ayumi Chikusa
Kyushu University, Japan, chikusa.ayumi.714@s.kyushu-u.ac.jp

Mr. Naoki Hiraiwa
Kyushu University, Japan, hiraiwa.naoki.978@s.kyushu-u.ac.jp
Dr. Mai Bando
Kyushu University, Japan, mbando@aero.kyushu-u.ac.jp
Dr. Shinji Hokamoto
Kyushu University, Japan, hokamoto@aero.kyushu-u.ac.jp

GUIDANCE AND CONTROL ALGORITHM FOR MARS AEROCAPTURE CONSIDERING UNCERTAINTIES

Abstract

In recent times, Mars exploration is getting attention, although large thrust is required to inject a vehicle into Mars orbit. This indicates the payload ratio of vehicles is restricted for chemical propulsion. Aerocapture is one of the useful trajectory transformation methods. However, it is subject to atmospheric turbulence and/or modeling errors of the atmospheric density and drag. Generally, a small bank angle is given to a vehicle at atmospheric entry phase for avoiding saturation of control input and preparing a larger angle requirement at a certain time during atmospheric flight. In previous studies, it has been shown that the optimal bank angle history has a form of bang-bang control, and some guidance algorithms have been proposed to increase trajectory tracking accuracy by sequentially solving the convex optimization and updating the optimal trajectory. However, such short-interval optimization cannot take the uncertainty of atmosphere into consideration.

This study focuses on guidance and control strategy for aerocapture considering uncertainties. Without taking into considering uncertainties, numerical analysis reveals that the spacecraft would crash to the ground if the bank angle change timing is too early. On the other hand, when the change in bank angle is delayed, more velocity increment ΔV is required to stabilize the trajectory without uncertainties. Therefore, earlier bank angle change in the successful trajectories is desirable in terms of ΔV, however such earlier input is more sensitive to atmospheric uncertainties. Moreover, the computational cost is expensive to solve optimization problem every time step. To address this problem, we propose an event-triggered approach for the convex optimization problem of bank angle profile. The objective function is the L1 norm of the bank angle, which updates the reference trajectory only when the deviation between the reference and ideal trajectories becomes some threshold considering the altitude, velocity, and flight path angle. In addition, this paper proposes a method to avoid a crash trajectory by adjusting multiple times of bank angle inputs. Monte Carlo simulation of aerocapture trajectories with initial errors and uncertainties show the effectiveness of the proposed method. The proposed method enables Mars aerocapture missions with less-thrust and not too-long operation, under no accurate atmospheric-model.