Paper ID: 76133

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

Author: Mr. Tomohiro Ishizuka
ISAE-Supaero University of Toulouse, France, Tomohiro.ISHIZUKA@isae-supaero.fr

Prof. Stéphanie Lizy-Destrez
Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), France,
Stephanie.LIZY-DESTREZ@isae-supaero.fr
Dr. Naoya Ozaki
ISAS/JAXA, Japan, ozaki.naoya@jaxa.jp
Dr. Kenshiro Oguri
Purdue University, United States, koguri@purdue.edu

6-DOF AUTONOMOUS AND ROBUST GUIDANCE FOR ASTEROID LANDING

Abstract

Plenty of asteroid exploration missions have launched in recent years and more missions are planned in the near future. Landing on an asteroid is an important phase of the mission to obtain variable scientific data which is not accessible from orbits, and allows to obtain materials for a sample return mission such as Hayabusa, Hayabusa2 and OSIRIS-REx missions.

Asteroid landing guidance is an interesting but challenging topic due to several factors. First of all, because of the great distance between the Earth and an asteroid, communication with a spacecraft suffers from a long time delay, which makes the real-time operation from the ground station impossible. Especially when the spacecraft is near the asteroid surface, quick action is needed to protect the spacecraft from colliding with the surface. Hence, autonomous, on-board guidance is inevitable. However, on-board guidance is not an easy task either since the on-board computational capability is significantly lower than that of on the ground, so a computationally efficient guidance algorithm is required. In addition, the guidance needs to take into account uncertainties which come from, for instance, the asteroid gravity model, spacecraft dynamics, spacecraft control and navigation system, or external perturbations. Ignoring the effect of the uncertainties in guidance can bring a spacecraft far from the desired arrival point.

Several methods have been proposed to achieve the autonomous asteroid landing optimization, including using the sliding mode control, the model predictive control, the convex optimization and the deep neural network. Among these studies, only a couple of them discuss 6 degrees of freedom (DoF) landing optimization, and there is no study that discusses the robustness against the uncertainties in 6-DoF guidance.

Therefore, in this work, we develop an autonomous, robust guidance method for 6-DoF asteroid landing. Our optimization strategy consists of two steps. In the first step, a reference landing trajectory and reference attitude are computed using the convex optimization techniques which has a capability to handle a highly- constrained optimization problem with less computational load than other optimization methods. In the second step, the stochastic optimal control method is used to compute the robust trajectory to follow the reference trajectory and reference attitude under the influence of the uncertainties. The Monte Carlo simulation will show the autonomous performance and robustness of our optimization method.