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IMAGE-BASED AUTONOMOUS NAVIGATION OF HAYABUSA2 IN 2ND TOUCHDOWN: NEW CHALLENGES AND IN-FLIGHT RESULTS

Abstract

Hayabusa2 is an asteroid sample return mission by Japan Aerospace Exploration Agency. Its scope

includes the world's-first landing on the near-Earth C-type asteroid Ryugu (162173), collecting samples from the surface and return to the Earth. The spacecraft was launched on 3 December 2014 by the H2A launch vehicle. After 3.5-years interplanetary cruise, it has arrived at the target asteroid Ryugu on 27 June 2018 and started proximity operation. We successfully performed critical descent operations such as the middle/low attitude reconnaissance, free descent for gravity estimation, deployment of MINERVA II and MASCOT rovers, the twice touchdown operations accompanied with the impactor mission, and the sample retrieval on the Earth in 2020.

Sample return missions from asteroids require autonomous final descent and landing of the probe onto the aiming point on the asteroid's surface, because the round-trip time of interplanetary communication is likely to be too long to operate final descent and landing from the ground station directly. In the asteroid proximity phase of the Hayabusa2 mission, autonomous navigation and control at the low altitude was performed by using the Target-Marker Tracking (TMT) technique, an image-based tracking of an artificial landmark called Target Marker (TM). In this scheme, TMs which are deployed from the hovering probes are used as artificial landmarks on the natural terrain. Though TMT method was successfully applied to the 1st touchdown, we found the degradation of optical systems including navigation cameras and altimeters after the landing, which may affect the TMT performance in the 2nd touchdown. It was assumed to be due to regolith adhesion to the optical systems. We assessed its impact on the image-based navigation and introduced several new challenges, which led to success of the 2nd touchdown. This paper describes basic design of TMT methods, new attempts to compensate for the degradation, numerical simulations, onboard parameter tuning, and in-flight results in the 2nd touchdown operation.