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Author: Mr. Tetsuya Kusumoto
The University of TOKYO, Graduate school, Japan, kusumoto.tetsuya@ac.jaxa.jp

Dr. Osamu Mori
Japan Aerospace Exploration Agency (JAXA), Japan, mori.osamu@isas.jaxa.jp

GUIDANCE AND CONTROL FOR LANDING ON AN ASTEROID USING DEPLOYABLE AND IDENTIFIABLE LANDMARKS

Abstract

Small body missions have been paid great attention to since we can gain the information of an early solar system. In order to obtain asteroid samples, a spacecraft needs to achieve landing on asteroids as Hayabusa2 and OSIRIS-REx did. During the proximity phase, autonomous guidance and control must be conducted due to the communication delay with the on-ground station. For this purpose, a spherical landmark called target marker has been utilized for the guidance and navigation of touchdowns in the Hayabusa2 mission. Although a spacecraft can land near the target marker, the marker is not always deployed near the point that the spacecraft wants to land on. Thus, we propose to deploy another marker when one target marker is deployed far from the target landing point. This strategy enables a spacecraft to achieve touchdown near the target landing point with high accuracy. Since target markers used in past missions are spheres and they cannot be distinguished, we propose a new target marker that is a membrane with a pattern on its surface, making it to be identifiable. Having a pattern has another advantage that a spacecraft can estimate altitude from the marker. In this study, we propose a new type of target markers and establish a guidance and control law of a spacecraft utilizing the multiple target markers on the asteroid surface for conducting accurate landing.

We have developed a prototype of a novel target marker that is a deployable membrane. This artificial marker is composed of a membrane, three nodes, and three booms. The booms are extensible, enabling self-deployment after the release of the marker from a spacecraft. Retroreflective sheet is attached to the surface of the membrane and the markers become identifiable.

We investigate a guidance and control method exploiting multiple markers deployed on the asteroid surface. When multiple markers are on the ground, our method produces the trajectory that achieves precise landing considering each marker position. Also, altitude inferred from a marker pattern is utilized. We conduct a numerical simulation and confirm that our proposed method enables more accurate landing compared with a conventional target marker. Also, we experiment using a 3dof motion simulator with prototype markers and demonstrate the feasibility of our landing strategy. These results confirm that the proposed deployable marker is a viable option for use in the guidance and control for precise landing on an asteroid.