ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation, and Control (5)

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IMAGE BASED NAVIGATION AND GUIDANCE FOR APPROACH AND TOUCHDOWN PHASE TO AN ASTEROID UTILIZING CAPTURED IMAGES AT THE REHEARSAL OPERATION

Abstract

It is necessary to use data for Ground Control Points (GCP) such as rocks and holes which stand out and are highly visible on the surface of a asteroid in order to precisely guide a spacecraft to desired landing/sampling position on a asteroid. The essential information on position, shape, size and distribution of GCPs is unknown until a spacecraft reaches to the proximity of asteroid. Therefore, it is necessary to correct such information before the actual touchdown for successful operation. In November of 2005, Hayabusa performed touchdown to the surface of asteroid Itokawa twice. In order to navigate and guide Hayabusa to the asteroid with unexpected shape and surface features as well as failures of attitude control devices, ground based terrain recognition, navigation and control utilizing captured images beforehand was performed and the guidance accuracy of around several tens of meters were achieved. As an extension of this experience, it expected to be highly desirable to correct information for GCPs utilizing image data captured during rehearsal descent before the actual approach and touchdown. The scenario can be summarized as follows. (1) Construct shape, dynamic model, topographic relief maps, and GCP positions from images taken at Home Position (HP) with long distance from an asteroid such as 20km . (2) Determine the sampling point and the descent path plan to the point. (3) Guide the spacecraft by ground based navigation using GCPs according to the above determined path plan (="Rehearsal Descent"). The spacecraft is brought back to HP when the spacecraft reaches near the surface such as 50 m altitude. (4) During the descent, the spacecraft sends the images of the surface taken by telescopic camera and wide-field camera. (5) Extract the feature points from the images of the rehearsal descent. The positions of feature points are reconstructed. The images and reconstructed position of feature points in asteroid frame are compiled as data base for onboard software, GCPDB (GCP Data Base). (6) The GCPDB are uploaded to guidance software of the spacecraft. (7) The spacecraft descends to the sampling point along the planned path (="Sampling Descent"). Using GCPDB information, the spacecraft searches the corresponding feature point in the real time camera image. The onboard navigation filter determines the spacecraft position in asteroid frame using the positions of the matched images in camera frame.

This paper proposes the result of the numerical simulation for above navigation and guidance algorithm.