CURRENT STATUS AND READINESS ON IN-SITU EXPLORATION OF ASTEROID SURFACE BY MINERVA ROVER IN HAYABUSA MISSION.

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Introduction

The Institute of Space and Astronautical Science (ISAS) of Japan has launched the engineering test spacecraft "HAYABUSA" to the near Earth asteroid "ITOKAWA" on May 9, 2003 [1]. HAYABUSA will go to the target asteroid after two years' interplanetary cruise and will descend onto the asteroid surface in 2005 to acquire some fragments, which will be brought back to the Earth in 2007.

A tiny rover called "MINERVA" has boarded on HAYABUSA spacecraft as an in-situ explorer on the asteroid surface (Fig.1, Table.1) [2]. It will be deployed onto the surface immediately before the spacecraft touches the asteroid to acquire some fragments. After the deployment, it will autonomously move over the surface by hopping for a couple of days and the obtained data on multiple places are transmitted to the Earth via the mother spacecraft while HAYABUSA remains near the asteroid before the departure for the Earth.

This paper describes the plan and the strategy to acquire surface images of the asteroid concentrated on how to set the parameters of the onboard camera.

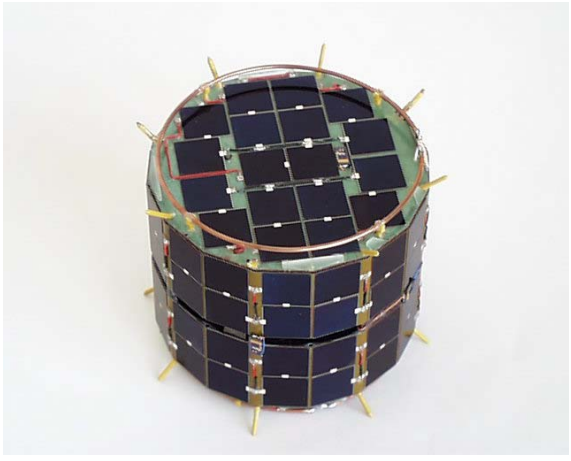

Figure 1: Flight model of MINERVA rover

Onboard Sensors

The rover has three color CCD cameras to capture the surface images and six thermometers to measure the surface temperature.

There are camera windows at the center of the side faces of the rover, through which the cameras view the outside. All the cameras are basically identical and sensitive in visible wavelength. Two of the cameras, which consist of a stereo pair, are set to observe nearby scenes and the last one is for more distant views.

There are pins sticking out from the rover body to protect the solar cells. Six of the pins are also used as thermal probes, by which the temperature of the surface is directly measured.

Camera

The cameras are commercially available, slightly modified in consideration of the use in the outer-space. The parameters of the camera are white-balance and shutter speed.

There are two image acquisition mode; automatic and manual, which can be selected onboard. The automatic mode is originally equipped with the camera. In the automatic mode, the parameters are automatically adjusted by the firmware of the camera when the image is captured. The actual used parameters can not be unknown. So the automatically captured images may be beautiful with no saturation, but the physical value can not be derived from them.

In the manual mode, the parameters are specified by the command from the Earth. The authors conducted pre-flight calibration test of the cameras and found out the best parameters to be used on the asteroid surface whose albedo is known in advance.

The estimated albedo of the asteroid surface may be different from the real one. Thus in our image acquisition strategy, the image capture process on the first day of the exploration will be conducted in both automatic and manual modes. Then the parameters are evaluated and readjusted on the ground by using the captured images and the revised parameters are sent by the command, which are used after the second day of the exploration.

Table 1: Rover Specifications

size	hexadecagonal pole (diameter: 120[mm], height: 100[mm])
mass	591[g]
CPU	32bit RISC CPU, clock 10[MHz]
memory	ROM: 512[kB], RAM: 2[MB], Flash ROM: 2[MB]
temperature range	-50 $\sim$ +80 [°C]
hopping ability	9[cm/s] (max)
power supply	solar cells: 2.2[W](max), 1.6[W](min) 1[AU] from the Sun capacitors : 5[V],25[F]
communication	9,600[bps] (communicable distance: 20[km])
sensors	three CCD cameras six thermometers six photo diodes

Autonomous image acquisition strategy

MINERVA rover moves over the asteroid surface by hopping. The surface exploration process is the iteration of hop and observation.

The rover has six photo diodes (PDs) to sense the incoming light. By using the value of the PDs, the onboard software estimates whether the rover is moving or not.

When it is estimated to be still on the asteroid surface, the surface image acquisition by the stereo pair of the cameras and the measurement of the surface temperature are conducted. Then the rover hops. After hopped into the free space with the ballistic orbit, the rover slightly rotates and the intensity sensed by the PDs are changing. During hopping, the rover captures the series of surface images by the other camera which views the distant scene.

Conclusion

This paper describes the surface image acquisition strategy of MINERVA rover onboard the HAYABUSA spacecraft. The rover will arrive at the asteroid in 2005 and the camera parameters used for the exploration are now ready.

References

[1] HAYABUSA website. available: http://www.muses-c.isas.ac.jp

[2] T. Yoshimitsu et al., "Scientific Capability of MINERVA Rover in Hayabusa Asteroid Mission," 35th LPSC, 2004.