Localization of Asteroid Probe Based on Range Measurement Using Radio-Wave-Marker on Asteroid Surface

Hirokazu Ishida,[1*] Yuichi Tsuda[2]
[1]*The University of Tokyo, Japan;* [2]*JAXA, Japan*
ishida.hirokazu@ac.jaxa.jp

Keyword : Asteroid exploration, Radio-wave-marker, Asteroid rover

Asteroid exploration has been attracting many space agencies in the world. Asteroid exploration missions often include touchdown maneuver and stationary observation. These operations require accurate localization of the probe. Getting the profile of the asteroid by optical sensors is a common way to estimate the position of the probe. This method, however, has high performance only when the distance between the probe and the asteroid is short. Moreover, this approach can only be used in the case that the area in the image is under sunlight. Other optical navigations method, such as feature point matching and method that using target markers, also have same drawbacks.

As a solution to these problems, this paper will propose time-series-filtering method measuring the range between the probe and radio-wave-marker (RWM) on the surface of the asteroid. Here we define RWM as a device by which the probe can measure the distance between itself and the device using radio waves. The state estimation by range measurement using radio-waves itself is a standard technique in aerospace navigation. The value of this research, however, lies not only in its application to a new domain but also in its extensibility. One potential extension is the RWM capable of moving around the asteroid surface. This function enables flexible placement of RWMs through the mission, by which potentially risky maneuver such as orbiting around the asteroid could be possible. Japanese asteroid probe "Hayabusa2", which was launched in 2014, is now carrying four rovers to the asteroid "Ryugu"[1]. These rovers are equipped with range measurement system, and also has high mobility by exploiting the microgravity environment of the asteroid[2]. In this context, the concept of the RWM with mobility is realistic.

As a preliminary step of this extension, this paper addresses the case where a rover equipped with RWM is stationary on the asteroid. We performed simulations and evaluated the accuracy of localization of the probe by proposed method. The parameters of the probe and asteroid were set to similar to those of "Hayabusa2" and "Ryugu", respectively. Fig. 1 shows one of the simulation results. In this simulation, the initial state of the probe was set to be stationary and about 20km away from the asteroid.

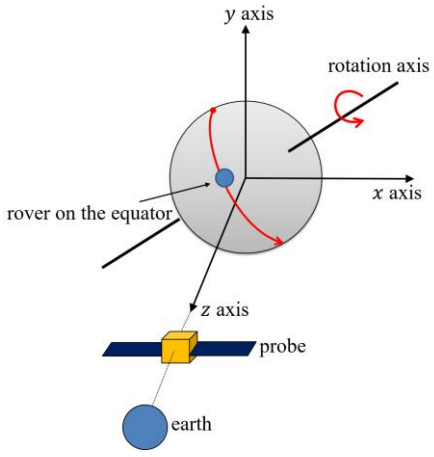

Fig. 1 Coordinate and configuration in the simulation.

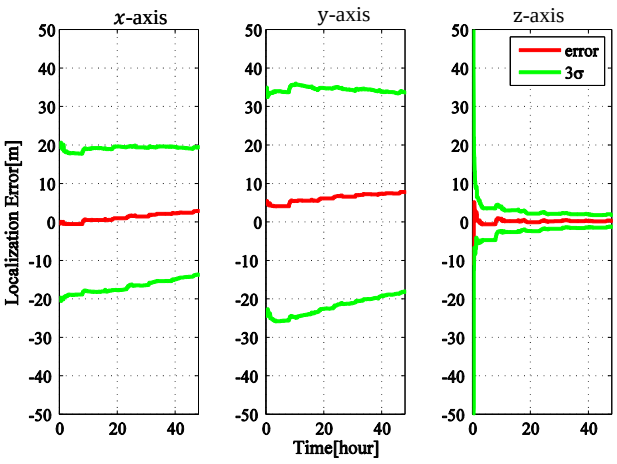

Fig. 2 Localization error and 3σ region.

References

[1] Tsuda, Y, *et al*, System design of the Hayabusa 2—asteroid sample return mission to 1999 JU3, *Acta Astronautica*, **91** (2013): 356-362.

[2] Yoshimitsu, T, *et al*, Proposal of range measurement experiment using a balloon, *Balloon Symposium: 2015*, (2015). (in japanese)