Position and Displacement Estimation Using Crater-based Line Segments for Pinpoint Lunar Landing

Kazuki Kariya,[1*] Takayuki Ishida,[2] Shujiro Sawai,[1,2] and Seisuke Fukuda[1,2]
[1]*SOKENDAI(The Graduate University for Advanced Studies), Japan;* [2]*JAXA, Japan;*
kariya.kazuki@ac.jaxa.jp

Keyword : Pattern Matching, Position Estimation, Pinpoint Landing, TRN, FPGA

Next generation planetary exploration mission targeting Moon, Mars and asteroids will require autonomous pinpoint landing capability because of requirement for landing on scientifically interesting terrain in a limited area. This capability requires precise absolute localization of the lander during braking descent phase and vertical descent phase. However, this requirement is not fulfilled with current inertial navigation. In planetary exploration, without real-time communication with the ground, radio sign, or GPS (Global Positioning System) satellites help, the navigation system can only rely on terrain sensors. Especially an image sensor is chosen as it is cheap, lightweight, and high versatility. From this point of view, some research have been performed to estimate position during EDL (Entry, Descent and Landing) by image-based method, such as TRN (Terrain Relative Navigation) [1].

This article proposes an image-based solution to the pinpoint landing problem: crater coordinates extracted from a descent image are compared with an image of previous frame or a crater database that was prepared from DEM (Digital Elevation Map) taken by preceding orbiters. We focus on the landing sequence shown in Fig. 1. In braking descent phase (at about 15 km altitude), the lander should perform position estimation precisely using an extensive database to reduce the inertial error. Yet in vertical descent phase (at 10 m ~ few km altitude), understanding displacement of the image from the previous frame is more important than localization because of horizontal velocity cancellation for safe landing. There is a common part to the solutions of these two estimation problems. By realizing these two different methods with one algorithm, it is possible to reduce computational cost and to improve robustness by using in combination with other sensors.

Our method estimates the lander position and horizontal displacement from matches between crater coordinates extracted from a descent image and database or images each other. For real-time calculation, this method uses crater-based linear features.

We will present about this crater matching method, and the evaluation of performance and mountability.

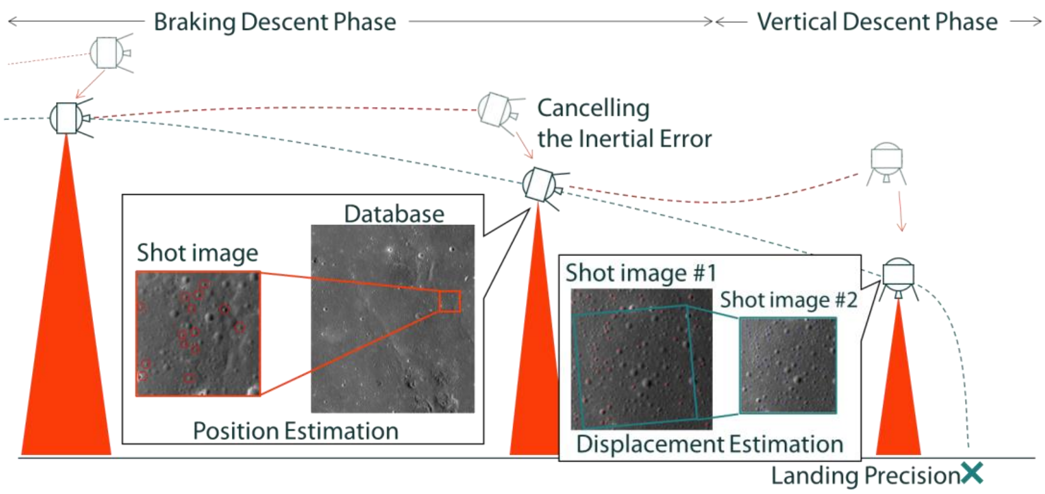

Fig. 1. Landing Sequence

References

[1] A. E. Johnson and J. F. Montgomery., Overview of Terrain Relative Navigation Approaches for Precise Lunar Landing., *Aerospace Conference, 2008 IEEE*, IEEE (2008), p. 1-10.