ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations (IP)

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PRELIMINARY STUDY ON VERTICAL DESCENT GUIDANCE FOR PRECISE LUNAR LANDING

Abstract

Scientific interest on the specific lunar areas has been increasing since the past lunar exploration missions such as Selenological and Engineering Explorer (SELENE) and Lunar Reconnaissance Orbiter (LRO) revealed the detailed lunar terrain features. This has been raising the importance of the in-situ exploration on the Moon. Above these background, precise landing technology in the order of 100 meters from the target is becoming a key to realize the in-situ investigation.

The final phase, before a couple of hundred seconds from landing, plays an important role for the precise landing. This phase is often called "vertical descent phase", in which the spacecraft vertically descents until touchdown. During the vertical descent phase, the preparation actions to land have to be taken continuously or simultaneously such as vertical braking, terrain relative navigation (TRN), position correction maneuver, and obstacle detection and avoidance. In terms of guidance trajectory, the following two characteristics should be taken into account.

1. Fuel consumption to be minimal.
2. Maneuver time for horizontal position correction to be minimal.

First, allocating extra fuel budget to the vertical descent phase leads to reducing almost the same payload weight. Therefore, minimizing fuel usage is significant, particularly for a small lander that has strong limitation on its payload capability. Second, this phase have to rely on TRN, so that correcting the position errors faster allows a spacecraft to obtain earlier the information around the landing site, which

contributes to safe and precise landing. In addition to these two points, guidance trajectory should be calculated onboard easily in accordance with occasional update of TRN information. Furthermore, it is desirable a guidance law has quantitative indexes showing how much margin the calculated trajectory has for safety and precision of landing. These are unique to "precise" lunar landing, hence a guidance law should be different from the traditional ones.

This paper first investigates the requirements on a guidance law of the vertical descent phase. One effective solution is then proposed, giving examples of JAXA's precise lunar landing mission called SLIM (Smart Lander for Investigating Moon) that aims to land from the designated site in the order of 100 meters.