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PERFORMANCE EVALUATION OF IMPROVED SELF-POSITIONING METHOD BASED ON CRATER SIZE FOR LUNAR LANDING VEHICLES

Abstract

Lunar exploration currently requires the pinpoint landing of spacecraft for scientific mission surveys. For such landings, guidance and navigation based on satellite self-position estimation with accuracy on the order of 100 meters is required. In addition, unmanned spacecraft have limited data storage and computation capacity due to their size and weight constraints and quick processing is preferred to reduce fuel consumption. High robustness is also required because external factors such as sunlight and satellite attitude are not always optimal.

Terrain relative navigation methods are considered to satisfy the storage and computation requirements. They estimate the spacecraft self-position by comparing lunar images taken by satellites with those in an onboard database. Past studies have been conducted to reduce the computational complexity and increase the processing robustness of these methods. Point pattern matching methods, specifically such as triangle similarity matching and direct matching, which use craters as feature points, have been proposed, and commonly used. However, there are some concerns about the practical use of such methods for spacecraft location estimation.

The SLIM project underway at JAXA plans to adopt the line segment matching method. This method selects two craters from a lunar image taken by a satellite, creates a line segment using the centers of the those two craters, then searches for an identical line segment in the database, using the center coordinates of the craters located near the line segment in the database as the evaluation value. The line segment matching method satisfies the above restrictions. However, it can still be improved in terms of computational cost.

In this study, we propose a method that utilizes the size information of craters to achieve faster location estimation than that of the conventional line segment matching method. The proposed method reduces the amount of processing for position estimation and speeds up computation by comparing the relative upward/downward position relationship of the center coordinates and the major or minor radii of two craters for the line segment in the captured image.

To compare the processing time between the proposed method and the conventional line segment matching method, we conducted simulations and experiments using an artificial lunar surface. The results show that the proposed method reduces the processing time for most cases. Estimation is accurate to less than 100 meters for most patterns when crater detection is successful. The usefulness of the proposed method is confirmed.