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Asteroid Shape Reconstruction using Structure from Motion

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A shape model of an asteroid is important for science analysis on exploring missions. In the Hayabusa mission, three models of asteroid Itokawa were reconstructed by different methods [M. Maruya, 2006], [H. Demura, 2006], [R. Gaskell, 2006]. A more precise model was reconstructed that have 3 millions or more polygons used multi-image photoclinometry after the mission [M. Maruya, 2006]. For the Hayabusa 2 project, a shape model of an asteroid 1999JU3 is also required. It must be investigated what reconstruction method is good. We focus on a method called Structure from motion (SfM) to achieve it. An open-source software Bundler [N. Snavely, 2006] implements SfM and Bundle adjustment [B. Triggs, 1999]. SfM is a method which uses multiple images to estimate real space coordinates of features in images and camera positions. Bundle adjustment is a kind of optimization method for non-linear model to estimate parameters on a geometric model precisely. A more precise result and less manual works are expected compared with ones in the Hayabusa mission by using and customizing the software. We reconstructed a shape model of Itokawa from 169 AMICA Images using this software. As a result, a sparse shape model is reconstructed successfully around equatorial region. However the number of points of polar regions are quite less than ones of equatorial region. This is caused by an insufficiency of images captured around a pole. We experimented this polar area observations using a shape model presented by [R. Gaskell, 2006]. In this experiment, we rendered the model and take images around of it with some longitude variations. One of the dataset is consists of images view from 30 degree longitude. The polar region is reconstructed successfully by inputting the dataset. And we also experimented with 70 degree and 80 degree longitude datasets for confirming the availability of Structure from Motion in the case of the rotation axis of 1999JU3 is parallel to the plane of revolution. The result was also good. Structure from Motion is useful for reconstructing asteroid shape model from multiple images. We are examining a method for quantitative evaluation of these results.

Keywords: Hayabusa, Hayabusa 2, 3D Shape Reconstruction