Solutions for control point coordinates and librations for the Saturnian satellite Dione: A simulation based on synthetic data

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We explore the application of the Inertial Frame Bundle Block Adjustment (IFBBA) to determine the shape and rotation state of small bodies, e.g., asteroids and natural satellites, using images acquired by spacecraft. Within this particular block adjustment implementation control point (CP) coordinates are tied to the body frame, while the camera parameters and the body's rotation state use a parameterization, referenced to the inertial frame (Burmeister et al., 2018). The flexibility is especially desirable for objects exhibiting notable (but poorly known) rotational variability, which often requires elaborate formulation depending on the regulating mechanisms.

Here we present a full simulation case, based on synthetic data for the Saturnian satellite, Dione. First, we studied the orbital characteristics of the satellite and computed the forcing terms for the longitudinal libration using a frequency analysis approach. We focus on the libration terms connected to the orbital period of 2.739 days and a long-period term of 11 years related to the resonance with Enceladus. We select around 1000 images of Dione collected by the Imaging Science Subsystem onboard the Cassini spaceprobe. Using a recent shape model by Gaskell et al. (2018), we establish a network of CPs with a more or less complete surface coverage.

Image coordinates of the CPs are simulated for the observing geometries and orientations of Dione at the given epochs of the images and are taken as observables in the adjustment. We test and extend the functionality of the IFBBA, previously applied to the Martian satellite Phobos and the asteroid 4 Vesta (Burmeister et al., 2018), to the present case. We analyze the estimation errors of the camera parameters, CP coordinates, and in particular, the retrieval of the libration amplitude for Dione. The outcome is expected to be instructive to the real data analysis in the future and shed light on the generalizability of the IFBBA software for other Solar System objects.

Reference

Burmeister, S., et al. (2018), Journal of Geodesy, 92, pp. 963–973, doi:10.1007/s00190-018-1112-8

Gaskell, R.W. (2020), Gaskell Dione Shape Model V1.0, NASA Planetary Data System, doi:10.26033/dh1c-ab91