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A Review of Image-based Small Planetary Body Shape Modelling

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Images are a powerful data source for modelling the shape of small planetary bodies, e.g., asteroids, comets, and many planetary satellites. The traditional stereo-photogrammetry (SPG), stereo-photoclinometry (SPC) methods have recently been joined by Deep Learning (DL) methods to achieve shape modelling. SPG and SPC methods have been applied previously to support various exploration missions, such as NASA OSIRIS-REx mission (Palmer et al., 2022), ESA Rosetta mission (Preusker et al., 2015), JAXA Hayabusa and Hayabusa2 missions (Gaskell et al., 2008; Watanabe et al., 2019), etc. To effectively achieve accurate 3D reconstruction, SPG methods require images taken under similar illumination geometry, as well as sufficient viewing coverage from different perspectives, while SPC methods prefer images involving illumination conditions.

Recently developed DL methods are divided into two modes. One of them involves using DL techniques to replace specific steps of the traditional methods in order to enhance shape modeling accuracy. For example, the matching process in the SPG method may be replaced by the DL technique to improve the matching accuracy (Chen et al., 2023). In contrast, the so-called "neural implicit methods" make full use of DL methods to replace the SPG method once accuracy in positions and orientations is attained (Chen et al., 2024). This approach can be trained and derive shape models end-to-end without any additional supporting work steps, showing a high potential as a complementary method for SPG and SPC. It is worth mentioning that the neural implicit method only needs a small number of images to train the model.

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