EPSC Abstracts
Vol. 19, EPSC2026-322, 2026, updated on 14 Sep 2026
https://doi.org/10.5194/epsc2026-322
Europlanet Science Congress 2026

Co-Registering MEX HRSC Image Data to Existing Shape Models for Photometric Analysis

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We present results of our efforts co-registering data from High Resolution Stereo Camera (HRSC) (1) on Mars Express to existing shape models of Phobos (2,3). There are numerous challenges when trying to align this data set with the derived topography. Nonetheless, the correct geometric alignment is of importance for the photometric analysis that is to follow.

HRSC is a line scanning stereo camera with angular separation between the forward- or backward-looking channels of up to 18.9 degrees (1) with respect to the nadir direction.

For the co-registration we use a classic photogrammetric approach that requires homologous points across several images. Other than on Mars where the single channels observe the surface at the same time providing additional geometric constraints, Phobos is too small and usually each channel observes the surface at a different epoch. The quality of homologous points is thus of great importance to geometrically stabilize the adjustment problem.

HRSC observes Phobos approximately every 5 to 6 months from a close distance due to orbit geometries of both Phobos and the Mars Express S/C. Flyby observations occur at irregular distances, and thus image pixel resolutions, and under a wide range of illumination conditions. Though important for the photometric analysis it constitutes an obstacle when it comes to finding homologues points between different flybys. To automate the matching process, we used the pre-trained deep learning models SuperPoint (4) for feature extraction and LightGlue (5) for feature matching. Before matching, Phobos is segmented in all input images, followed by contrast enhancement to help account for invariances across the observations. The nadir observations are matched pairwise across the whole dataset of different flybys. Thereby, all matching pairs undergo an outlier removal to improve robustness of the point correspondences. Finally, we used the same techniques to identify features correlating with confirmed matches in each associated channel, supported by least-squares matching (6) for a dense keypoint grid within one flyby observation.

A classic photogrammetric adjustment approach was used to achieve the alignment between the shape model and the image data. As the HRSC is a line scanning camera, the applied software (7) establishes virtual orientation points and interpolates the s/c trajectory and attitude between these orientation points. Co-registration with respect to existing shape models is achieved by introducing several landmark coordinates extracted from the shape models as ground control points in the adjustment problem. First tests show that a co-registration with an average accuracy below 1 meter can be achieved while the accuracy of the homologous points ranges within +/- 35m on average. This is a satisfying result showing that the co-registration to an existing reference works very well. The remaining error of the homologous points is in agreement with the average pixel resolution of the contributing images.

We will report on the progress and further results during the meeting.

Acknowledgements: A. Schriever is partially funded by the Deutsche Forschungsgemeinschaft

(DFG) – Project 528586639. The authors thank the HRSC Experiment teams for their successful planning and acquisition of data as well as for making processed data available to the HRSC team.

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