AN INTEGRATED APPROACH FOR ORTHOIMAGE AND DTM GENERATION USING MARS EXPRESS HRSC DATA

S. Gehrke [a, *], I. Schneider [a], J. Albertz [a], G. Neukum [b], and the HRSC Co-Investigator Team

[a] Technische Universität Berlin, Geodesy and Geoinformation Science, Berlin, Germany –
stephan@fpk.tu-berlin.de, i.schneider@gmx.de, albertz@fpk.tu-berlin.de
[b] Freie Universität Berlin, Institute of Geosciences, Berlin, Germany – gneukum@zedat.fu-berlin.de

Commission IV, WG IV/7

KEY WORDS: Extra-terrestrial, Planetary, Photogrammetry, Three-Line, Matching, Orthoimage, DEM/DTM

EXTENDED ABSTRACT:

Since the very beginning of 2004 the High Resolution Stereo Camera (HRSC) experiment on board of the Mars Express mission systematically covers the surface of our neighboring planet providing both full color and 3D. Nine channels are obtained simultaneously, in particular four color channels (red, green, blue, and infrared) as well as five panchromatic channels arranged in nadir and stereo angles between ±18.9°. These data sets are well suited to derive Digital Terrain Models (DTM) and color orthoimages. Systematic photogrammetric processing of HRSC data is based on image matching between nadir and stereo channel images. The resulting products, both orthoimage and DTM are of special importance for mapping purposes and geologic interpretations as well.

With regard to the combined derivation of orthoimage, DTM, and reflectance properties of the Martian surface, HRSC data are exemplarily processed using the Facets Stereo Vision approach. This allows for the integrated computation of such models and therefore implicitly considers the existing interconnections.

Facets Stereo Vision is a powerful and flexible method for image matching in object space. The object surface elements (surfels) are linked with the corresponding pixels in each image with radiometric transfer functions and, geometrically, through the well-known collinearity equations. Compared to classical image correlation, which comprises the matching of certain points or features, all pixels and therefore the entire image contents are treated as observables. Basically, the unknowns consist of the orthoimage (color or panchromatic brightness values) and the DTM (height values). The algorithm is flexible to the determination of further parameters, e.g. to represent the transfer function with a qualified surface reflectance model. All of these object properties are estimated in a combined least squares adjustment with respect to spatially regular grids, i.e. the facets. However, the sampling points do not have to be identical for different models – usually a DTM will have a lower resolution than the orthoimage. The interconnections are regarded by employing appropriate interpolation functions, which could be bilinear for most cases. In general, Facets Stereo Vision is flexible to different object and camera models.

As the HRSC camera is a line scanner, the common approach has been adapted to this specific geometry. While the images feature central perspective within the image lines, they are parallel projected along the Mars Express orbit; spacecraft position and attitude and therefore the camera orientation vary from line to line. This orientation is known with sufficient accuracy, if improved by bundle adjustment within the HRSC team. The inner orientation, i.e. focal length and pixel coordinates of each CCD line, has been calibrated. Thus, all of these parameters can remain unchanged in this investigation.

The indirect approach for Facets Stereo Vision is utilized for the processing of HRSC data. Thus – besides the definition of sampling points for the unknown parameters – so called pseudo orthoimages (i.e. pseudo observables) are resampled for each channel. In particular, the object surfels are projected into the HRSC images using adapted collinearity equations. Then both grey values and camera orientation are interpolated between adjacent image lines. The projection requires the known camera orientations as well as initial height values. The Mars Observer Laser Altimeter (MOLA) DTM is likely to suffice for this purpose. Based on the pseudo observables, the orthoimage and height corrections with respect to the initial DTM are calculated. The entire algorithm has to be carried out iteratively, starting with the resampling of the pseudo orthoimages using the enhanced DTM heights, until the termination constraint (no significant height changes) is reached.

In the simplest case, the radiometric transfer function between the object and the images is unity. Within this study, linear functions have been applied to adjust contrast and brightness differences between the images. While the second approach is common photogrammetric praxis, it is not physically motivated; both cases do not model direction-dependant reflectance. Therefore, Lamberts reflectance law, which consists solely of the albedo parameter or the brightness of Martian surface respectively, is implicitly assumed. The implementation of a sophisticated reflectance model will be subject to future work.

The adapted algorithm of Facets Stereo Vision has been implemented with MATLAB. It is applied for different regions of Mars that feature varying surface characteristics and imaging conditions, e.g. with regard to illumination angles and resolutions. First results of this investigation will be presented.

* Corresponding author.