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Implementation of an ISIS Compatible Stereo Processing Chain for 3D Stereo Reconstruction

E. Tasdelen(1), H. Unbekannt(1), K. Willner(1) and J. Oberst(1,2)
(1)Technische Universität Berlin, Institute for Geodesy and Geoinformation Science, Planetary Geodesy, Berlin, Germany,
(2)German Aerospace Center (DLR), Berlin-Adlershof, German

1. Introduction

The department for Planetary Geodesy at TU Berlin is developing routines for photogrammetric processing of planetary image data to derive 3D representations of planetary surfaces. The ISIS software, developed by USGS, Flagstaff, is readily available, open source, and very well documented. Hence, ISIS [1] was chosen as a prime processing platform and tool kit. However, ISIS does not provide a full photogrammetric stereo processing chain. Several components like image matching, bundle block adjustment (until recently) or digital terrain model (DTM) interpolation from 3D object points are missing. Our group aims to complete this photogrammetric stereo processing chain by implementing the missing components, taking advantage of already existing ISIS classes and functionality. With this abstract we would like to report on the development of a new image matching software that is optimized for both orbital and close-ranged planetary images and compatible with ISIS formats and routines and an interpolation tool that is developed to create DTMs from large 3-D point clouds.

2. Matching Software Details

The matching software supports multithreading in order to increase the performance and to handle large images, such as Lunar Reconnaissance Orbiter Camera (LROC) data, efficiently. Currently supported image formats are Vicar, TIFF and ISIS CUBE. The Matcher integrates different area-based matching algorithms like normalised cross-correlation (NCC) and least-squares matching (LSM). NCC delivers an approximate value of disparity. LSM is applied in order to refine the result to sub-pixel accuracy. The definition of the search space, which is the maximum expected image coordinate difference (disparity) in overlapping stereo images, is the main difference between the approaches.

2.1 Matching Strategies

Matching without pre-processing, as the name implies, tries to determine conjugate image points in stereo images without applying any pre-processing. The search space is defined by the users. *Coarse-to-fine hierarchical matching* creates image pyramids from input images and performs matching on these images. The results from pyramid images are used to define the search space for the main matching runs. *Grid based matching* uses projective transformation in order to decrease the search space. Tie points and transformation parameters are calculated automatically. It follows the computation of the transformation for the whole image or smaller sized grids that are obtained after portioning the image. The latter, leads to unique transformation parameters and search space parameters for each defined section of the image.

3. Interpolation Tool

Large clouds of 3D object point coordinates are used as input data for the DTM interpolation. As a first step, these coordinates are map-projected into a pre-defined cube file, which serves as a target container. The input data can be provided in non-sequential order and there are no specific requirements in terms of spatial distribution or homogeneity of the distribution of the points. The point clouds may also have gaps. On the other hand, it is possible that several object points define only one pixel of the target projection. In our first preliminary implementation of the tool, this is accounted for by applying distance-defined weighting to determine exactly one value for the resulting pixel. The implementation of further interpolation methods is in progress. Envisaged methods are nearest neighbor, bilinear and bi-cubic interpolation. This will enable the user to define different interpolation radii and to define for instance how many points are needed to define one final pixel.

4. Results

The matcher was tested with two different stereo image pairs. The first data set contains close-range images that were acquired by a stereo camera during a field trial. The other data set are LRO orbital images. The results of the matcher presented here were carefully compared to the results of another image matching software, e.g. software used at DLR (Deutschen Zentrums für Luft- und Raumfahrt), with respect to number of matches found, completeness and quality of the visual 3D representation.

The first tests using close-range images showed that in terms of coverage and completeness, TU matcher delivers high quality results. However, it suffers from large number of outliers. Thus, a post-processing step was applied and mis-identified corresponding points were subsequently removed by applying different filter techniques. Figure 1 shows the resulting 3D reconstruction.

The second matching test was conducted on LRO orbital images. The resulting disparity map and visual control of the final DTM (Fig.2) show very good agreement with the 3D reconstructions from different software solutions [2].

The interpolation tool was tested with 3D points derived from stereo image matching of Lunar Reconnaissance Orbiter's Narrow Angle Camera (NAC) images and Mars Express' High Resolution Stereo Camera of the Martian Moon Phobos. A preliminary result is shown in Figure 3.

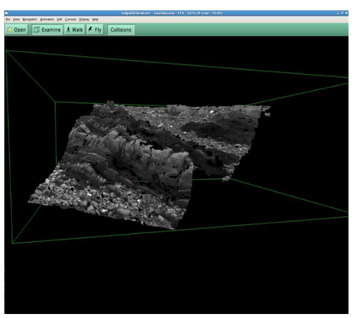

Figure 1: 3D Construction of Clarach Bay.

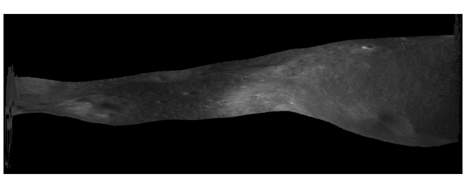

Figure 2: Perspective View of DTM from LRO Images.

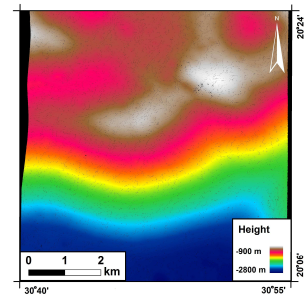

Figure 3: Subset of a preliminary DTM (1.5 meter/pixel) derived by our interpolation tool. Gaps within the terrain model, 1-2 pixels in size, are visible and were caused by inhomogeneous point distribution. (Area: North Massif adjacent to the Apollo 17 landing site.)

5. Future Works

More matching tests and comparisons based on different data sets will be performed in order to judge the capabilities of the software, especially, in terms of accuracy and completeness. The interpolation tool will be further assessed, by comparison of results with equivalent datasets from different software packages, when all interpolation methods are implemented. Results of the evaluation will be reported during the conference.

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