USING ADVANCED GEOMETRIC MODELS IN IMAGE MATCHING WITH HIGH RESOLUTION SPACE IMAGES.
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High resolution Digital Terrain Models (DTMs), suitable for geomorphological studies of planets and asteroids, are today among the main scientific goals of space missions. In the last decades, the great progress in high-resolution imaging of planetary surfaces (with ground-sample-distance that can reach 25 cm/pixel) finds two significant examples in the High Resolution Imaging Science Experiment (HiRISE) on Mars Reconnaissance Orbiter, and in the NAC of the Lunar Reconnaissance Orbiter Camera (LROC) on LRO. These images have provided the widest data-volume ever obtained before from any space mission and are characterized by strong potentialities associated with their astonishing capability of acquire details and features on the planetary surfaces.

The process for deriving DTMs starting from these raw data is very complex because it has to answer to two main requirements: operate very accurately and work with extremely large data volumes.

Nowadays the most important institutes involved in the planetary mapping are working on developing strategies to fulfil these requests. Despite the introduction of a series of new algorithms for image matching (e.g. the Semi Global Matching: [1]) that yield superior results especially in qualitative terms (smooth and continuous surfaces) and in terms of processing time, the common trend in the planetary-photogrammetry field stays in opting for the established area-based techniques and the efforts are more to improving each single phase of the photogrammetric process (from the image pre-processing stage to the final interpolation of the DTMs).

In this context, the Dense Matcher software (DM) developed at University of Parma has been recently optimized to cope with very high resolution images provided by the most recent missions (LROC NAC and HiRISE) putting the efforts mainly at the correlation phase and at the improvement of the process automation.

In order to improve the performance of the software, a new image correlation code based on advanced Least Squares Matching (LSM) algorithms has been developed.

Perspective changes due to terrain morphology are difficult to accommodate by an area-based stereo correlator. The solution has been the use of an iterative algorithm to adapt the correlation window with different shape functions. Many authors [2] found that the use of a simplified shape function leads to lower computational efforts but provides lower accuracy when significant changing in the terrain curvature occurs. Also Bethmann [3] showed that using different shape functions to model the geometric transformation in LSM can bring higher accuracy and solve, in some cases, numerical problems like pixel-locking. In this context, the new DM software uses, rather than the common affine transformation, alternative functional models in the geometrical transformation involved during LSM to handle perspective differences.

At the same time, working with orbital-space images, usually means to be able to manage large amount of data. Due to that, in order to guarantee good computational performances, efforts have been put in the optimization of the processes developing new strategies (grid-matching and tile approach).

Since the stereo-recontruction is strongly correlated to the quality of the image-correlation process (that in many cases can produce outliers and mis-matches) leading to uncorrected interpretations of the topography, a comparison between uncorrelated data (that don’t participate in the generation of the DTM) as the laser height points can be used to assess the effective height resolution and the exterior quality (accuracy) of the photogrammetric product.

The paper first describes the main features of the optimized version of Dense Matcher, with particular regard to the mathematical model implemented in the Least Squares Matching. Then, the performance of the image correlation kernel of the program is evaluated through comparisons with DTMs generated by other well established software like Socet Set by Bae System and Ames Stereo Pipeline (NASA) on HiRISE stereo pairs. Finally a comparison is also made with the DTMs produced on NAC stereo-pairs by the Vicar software by DLR (German Aerospace Center), as well as against the LOLA altimeter tracks.

The results look very promising and represent a concrete proof of the capability of Dense Matcher in dealing with two of the most significant examples of high resolution orbital imaging: HiRISE images and the ones acquired by NAC.

References:

[1] Hirschmuller, H. (2005) Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. [2] Sutton & al., (1988); Bruck & al., (1989); Lu & Cary(2000); Hubert & al.(2002). [3] Bethmann & al., (2010).