XXI Congress

ernational Society for Photogrammetry and Remote Sensing
3-11 July 2008, Beijing China

ABSTRACT SUBMISSION FORM

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Title of the Paper : **VERY HIGH RESOLUTION STEREO DTM EXTRACTION AND IT'S APPLICATION FOR SURACE ROUGHNESS ESTIMATION OVER MARTIAN SURFCE**	
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Technical Session [3] WG IV/7 – Extraterrestrial Mapping	
Keywords (5-8) [4] Planetary, Geology, Automation, Imagery, GIS, DEM/DTM, Fusion, Algorithms	

We have developed a processing system to extract very high resolution DTMs up to 0.5m from HiRISE Stereo image pairs [1]. This system includes automated DTM noise reduction within the extraction process. The system has been applied to simulate the effects of surface roughness data by combining HiRISE and HRSC stereo DTMs to try to interpret MOLA beam broadening effects in a quantitative manner.

HiRISE processing : Currently the best possible stereo coverage of Martian surface is from HRSC imagery. However, the accuracy, grid-spacing and reliability of reconstructed 3D Martian surfaces from HRSC stereo pair with 12.5 m spatial resolution is still not ideal for certain geological applications, e.g. surface roughness extraction for estimates of surface erosion. The successful deployment of the NASA MRO with the 25cm HiRISE instrument provides an opportunity to address this issue for up to 1% of the surface by the end of the nominal mission. One of the difficulties in fully exploiting the potential of HiRISE for photogrammetric products is that there are some technical issues to use the tracking information for sensor modelling [2]. Therefore, we have started by developing a simple workaround mapping method for HIRISE imagery which appears to produce a reasonable quality set of mapping products including 0.5-4m resolution stereo DTMs and 25cm orthoimages over various HiRISE stereo observation areas. This approach is based on a sensor modelling method employing HRSC intersection points for control information [3]. To produce correct registration between 12.5m resolution HRSC and 25cm HiRISE image, a scheme was developed using a hierarchical processing chain and an efficient image matcher which combines both epi-polarity and ALSC (adaptive Least Squared Correlation) refinement methods at each stage. Also image matching noise and sensor characteristics (due to the nature of the TDI chips employed) are quite effectively removed by a multi stage iteration surface matching method. This method can produce DTMs with a resolution from 0.5-4m according to the processing stage. Using such a simple approach, a number of recent improvements in our HiRISE stereo processing chain are under development which show encouraging results.

1) In addition to the point matching between HRSC and HiRISE to define common control points, a surface orientation adjustment between HRISE and HRSC intersection point clouds was tested. This can greatly improve the accuracy of HiRISE SPICE kernel pointing information. The updated SPICE kernel together with our current non-rigorous model can significantly decrease our current error of around 60m horizontal shift between HRSC and our HiRISE mapping products. 2) a more sophisticated matching system employing sensor information and illumination are under development to try to attain the maximum possible DTM resolution.

Such improvements guarantee less noise and more accurate mapping products so the HiRISE DTM products are applicable to surface roughness extraction purposes. The resolution of HiRise is such that small boulders and rocks can be identified within a landscape leading to the intriguing possibility that very high resolution DTMs can be used to quantify the well-known lidar beam broadening effect which has been observed with MOLA.

LiDAR Simulation : The highest possible HiRISE DTM resolution can be up to 0.5m with our approach. To simulate a lidar footprint of 150m, we need to find an area with slopes<2º with similar characteristics over 150m so that any unknown misregistration between HiRise, HRSC and MOLA will not unduly affect any simulations. Monte Carlo ray tracing simulations [4] have been run with 0.5m HiRISE DTM over a variety of different ares where HiRise stereo is available. For these areas, we located the best possible co-registration between received MOLA pulse width and simulated values. These results have been employed to provide a correction term for the influence of the surface slope parallel to the nadir direction to estimated local roughness as Gardner [5] proposed.

HRSC DTM extraction : HRSC stereo DTMs are still a very important source of topographic slope data in our processing. Since the accuracy of the extracted surface roughness is largely dependent on HRSC DTM quality, a processing scheme to make relatively noise free intersection points cloud is employed. A so-called “front end” image matcher based on the Zitnick and Kanade [6] algorithm has been employed to generate high density seed points for ALSC refinements. The intersection points from this matching scheme and HRSC sensor model are compared with MOLA to remove any significant outliers by a slope analysis. Then the median filtered values within 75m resolution which is the same as half of the MOLA footprint size are extracted. Such processing provides a better natural sloped height surface so that the calculated local roughness values from this DTM are relatively free from the influence of any height outliers and uncorrelated with the slope.

Surface roughness extraction : All data to extract RMS vertical local roughness from the MOLA pulse width up until now exclude any slope influence and are prepared using the methods which are described above. Compared with all previous research on local roughness extraction which usually employed a gridded MOLA DTM, this approach clearly gives more “uncorrected” local roughness estimation with the slope. In some HiRISE stereo areas, the local roughness values from HRSC and MOLA beam pulses are compared and verified with the ones which are directly estimated from the height variation of HiRISE stereo intersection points. Our target areas are parts of the Elysium Planitia and Iani Vallis.

Conclusion : Local surface roughness maps have been constructed from HRSC DTMs and MOLA pulse width. These values have been verified using HIRISE DTMs. These local roughness extraction procedures will provide data sets for a better understanding of Martian surface process and the selection of landing sites as well as for correcting MARSIS and SHARAD sub-surface low frequency radio.

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