Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11490, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11490
EGU General Assembly 2008

3D crater data base construction using automated and manual components for crater morphology

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Impact crater databases are a key resource for planetary geologists. Uses include studies of relative and absolute surface ages/chronologies, erosional processes, hydrological evolution and climate history. 3D databases are of particular interest for these applications.

This work describes the creation of 2D and 3D Mars crater databases from high resolution HRSC and HiRISE stereo imagery using data fusion and automated crater detection methods for the morphometric classification of craters.

To construct reliable 3D crater database over a wide area, it is necessary to integrate 2D crater boundary information with various sources of range data such as MOLA, HRSC stereo DTMs and HiRISE DTMs. Therefore, the introduction of automated crater detection is desirable in order to be able to exploit these new sources of data given the large data quantities entailed. In addition to the application of automated feature extraction, it is also necessary for the foreseeable future to employ manual verification, correction and insertion of craters missed by the automated process. A semi-automated process has been developed as part of a software GIS tool to facilitate the statistical assessment of detection rates and quality with minimal human interaction. This allows very rapid (one crater/second or less) completion of the automated crater database using a skilled geologist.

Two study areas on Mars were chosen for initial testing: Elysium Planitia and Iani Vallis. HRSC image data strips for these areas were processed with the Kim-Muller automated crater detection algorithm [1] to generate 2D data sets including crater centres and radii. Software ws developed to detect overlaps in craters from overlapping image strips and automatically merge the results.

2D crater boundaries resulting from the process described are important clues to reconstruct a 3D crater model. The best possible 3D Profiles for various scale ranges were extracted from a Digital Terrain Model (DTM) created using high quality HRSC and HiRISE stereo imagery. The detailed methods to extract stereo DTMs over craters at resolutions as fine as 1m are described in Kim and Muller [2]. The stereo intersection points within all sizeable ($r > 400$m) 2D crater boundaries detected by the automated crater detection algorithm were verified by surface matching [3] employing an ideal 3D crater models as a reference surface and the outlines were removed. Next, the 3D shapes of detected craters were reconstructed from noise free intersection points and 3D GIS datasets were created using multipatch shapefiles. Normalized coefficients for fitted polynomials were then calculated and applied to generate several ideal 3D crater models. Then extracted 3D craters can be classified by shape and diameter/depth ratios. For small impact craters ($r < 320$m), a shape from shading algorithm using the base stereo DTM from polynomial fitting was applied to construct 3D shape.

All extracted 3D crater data is exported into a GIS program such as ArcGIS Tin structure. The results of this research will provide significant enhancements to existing crater database creation methods and allow much more extensive areas to be processed during the creation of geomorphometric and geological products.

[1] Kim, J. R., Muller, J.-P., Gasselt, S. V., Morley, J. G., Neukum, G. & Team, H. C. (2005) Automated Crater Detection, A New Tool for Mars Cartography and Chronology. Photogrammetric Engineering & Remote Sensing, 71, 1205-1217. [2] Kim, J. R. & Muller, J.-P., (2007) Very high resolution DTM Extraction from HiRISE Stereo Imagery, European Mars Science and Exploration Conference [3] Mitchell, H.L. & Chadwick, R.G., (1999) Digital Photogrammetric concepts applied to surface deformation studies. Geomatica, 53(4), 405-411.