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information from imagery

ABSTRACT SUBMISSION FORM

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Title of the Paper : 3D Crater Database Production On Mars By Automated Crater Detection And Data Fusion
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ABSTRACT(800-1000 words) [5],[6]

Impact crater databases are a key resource for planetary geologists. Uses include studies of relative and absolute surface chronologies, erosional processes, hydrological evolution and climate history. With emerging techniques, 3D databases are of particular interest. After more than four decades of research and manual efforts, only a few tens of thousands of the billions of craters on Mars have been catalogued, mainly those ≥ 5 km diameter. Automated techniques for crater detection and cataloguing are therefore necessary to take advantage of the vast quantities of remotely sensed data available, especially now that 3D information is routinely available from the ESA Mars Express HRSC instrument.

For the results of automated crater detection systems to be useful, high levels of accuracy have to be achieved. This raises two immediate problems. Firstly, the accuracy of existing automated approaches is generally unsatisfactory and needs to be improved. Secondly, the absence of ground truth data makes it difficult to actually perform a meaningful and reasonably objective assessment. A further challenge is the development of a fully automated crater detection system capable of achieving accuracies of ≥99%.

This paper 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. A semi-automated process has been developed which incorporates a software GIS tool to facilitate the statistical assessment of detection rates and quality with minimal human interaction.

Two study areas on Mars were chosen, Elysium Planitia and Iani Vallis. HRSC image data for these areas were processed with the Kim-Muller automated crater detection algorithm [1] to generate results consisting of crater centres and radii. The results for the separate images were imported directly into a bespoke software tool for visualization, assessment and merging. This tool is designed to allow the rapid

tagging of craters as true positives (TP) or false positives (FP) as well as digitization of false negatives (FN).

The algorithm's performance was quantified for each individual image using Shufelt's metrics [2] developed originally for evaluating building extraction from aerial imagery:

*Detection percent = (100 * TP) / (TP + FN)*

*Quality percent = (100 * TP) / (TP + FN + FP)*

Branching factor = FP / TP

Detection rates were plotted against crater diameter in order to establish the diameter ranges for which acceptable detection rates were achieved by the algorithm. The lower limit for crater diameter was found to be 8 pixels and craters smaller than this were therefore not included in the quality assessment. The Shufelt metrics mentioned above were calculated and tabulated for each image and log plots of detection and quality percentage were created.

2D data sets for use in geographic information systems (GIS) were generated by automatically merging the results for each area. Craters in the overlapping area of images from adjacent orbits can appear in each of the overlapping results sets but are most often not identical. These duplicates had to be resolved. Candidate duplicates were identified using a distance measurement factor which incorporates distance between centres and ratio of radii. All candidate duplicates were iteratively tested to identify the closest matching pair of craters. These were then replaced with a single crater interpolated from the duplicate centres and radii.

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 [3]. Normalized coefficients for fitted polynomials were then calculated and applied to generate several ideal 3D crater models. The stereo intersection points within all sizeable (r> 400m) 2D crater boundaries detected by the automated crater detection algorithm were verified by surface matching [4] employing the ideal 3D crater models as reference surfaces 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. The 3D profiles could alternatively be created as triangulated irregular networks (TINs), multipoint shapefiles with Z (height) values or raster surfaces.

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☐ This paper would like to apply for the Young Author's Award [7]

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