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Local Surface Reconstruction from MER images using Stereo Workstation

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The authors present a semi-automatic workflow that reconstructs the 3D shape of the martian surface from local stereo images delivered by PnCam or NavCam on systems such as the NASA Mars Exploration Rover (MER) Mission and in the future the ESA-NASA ExoMars rover PanCam. The process is initiated with manually selected tiepoints on a stereo workstation which is then followed by a tiepoint refinement, stereo-matching using region growing and Levenberg-Marquardt Algorithm (LMA)-based bundle adjustment processing.

The stereo workstation, which is being developed by UCL in collaboration with colleagues at the Jet Propulsion Laboratory (JPL) within the EU FP7 ProVisG project, includes a set of practical GUI-based tools that enable an operator to define a visually correct tiepoint via a stereo display. To achieve platform and graphic hardware independence, the stereo application has been implemented using JPL's JADIS graphic library which is written in JAVA and the remaining processing blocks used in the reconstruction workflow have also been developed as a JAVA package to increase the code re-usability, portability and compatibility.

Although initial tiepoints from the stereo workstation are reasonably acceptable as true correspondences, it is often required to employ an optional validity check and/or quality enhancing process. To meet this requirement, the workflow has been designed to include a tiepoint refinement process based on the Adaptive Least Square Correlation (ALSC) matching algorithm so that the initial tiepoints can be further enhanced to sub-pixel precision or rejected if they fail to pass the ALSC matching threshold.

Apart from the accuracy of reconstruction, it is obvious that the other criterion to assess the quality of reconstruction is the density (or completeness) of reconstruction, which is not attained in the refinement process. Thus, we re-implemented a stereo region growing process, which is a core matching algorithm within the UCL-HRSC reconstruction workflow. This algorithm's performance is reasonable even for close-range imagery so long as the stereo –pair does not too large a baseline displacement.

For post-processing, a Bundle Adjustment (BA) is used to optimise the initial calibration parameters, which bootstrap the reconstruction results. Amongst many options for the non-linear optimisation, the LMA has been adopted due to its stability so that the BA searches the best calibration parameters whilst iteratively minimising the re-projection errors of the initial reconstruction points.

For the evaluation of the proposed method, the result of the method is compared with the reconstruction from a disparity map provided by JPL using their operational processing system. Visual and quantitative comparison will be presented as well as updated camera parameters. As part of future work, we will investigate a method expediting the processing speed of the stereo region growing process and look into the possibility of extending the use of the stereo workstation to orbital image processing.

Such an interactive stereo workstation can also be used to digitize points and line features as well as assess the accuracy of stereo processed results produced from other stereo matching algorithms available from within the consortium and elsewhere. It can also provide "ground truth" when suitably refined for stereo matching algorithms as well as provide visual cues as to why these matching algorithms sometimes fail to mitigate this in the future.

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