WIDE BASELINE MAPPING FOR MARS ROVERS: ACCURACY ANALYSIS AND AUTOMATED BUNDLE ADJUSTMENT.

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In NASA's Mars Exploration Rover (MER) mission, wide-baseline mapping technology was applied to improve the mapping capability of rover stereo images from tens of meters (hard baseline) to hundreds of meters. The wide baselines were generally designed empirically and cross-site (wide baseline) tie points for bundle adjustment (BA) were picked manually during mission operations. This paper presents a systematic accuracy analysis of wide baseline mapping and an approach to automatic wide-baseline tie point selection.

Wide-baseline mapping accuracy is affected by geometric parameters of the hard-baseline stereo camera, parallax measurement error, wide baseline error and orientation error. Based on theoretical analysis and numerical simulation, the optimal Pancam wide baselines are 6m for targets between 200m and 300m, 8m for targets between 400m and 500m, and 10m for targets between 600m and 700m. The corresponding mapping accuracy is at sub-meter to meter level.

The process of automatic wide-baseline tie point selection includes interest point extraction using Harris or Förstner operator, interest point matching by cross-correlation, outlier rejection by RANSAC-based fundamental matrix computation, least squares image matching for the inliers, and selection of evenly-distributed tie points in image grids.

We tested the developed method using MER Spirit's Pancam data acquired at sites APFI (on Sols 774 and 775) and APGB (on Sols 776 to 778) to map McCool Hill with a range up to 400m. The data was downloaded from the Planetary Data System (http://pds-imaging.jpl.nasa.gov/search/search.html). An image network was formed using the automatically selected tie points and BA is applied to the image network subsequently. After BA, the 2D accuracy is sub-pixel and 3D accuracy is 0.5m. This demonstrated the effectiveness of the automated BA and attainable accuracy of wide baseline mapping.