Landing Site Mapping and Rover Localization for the 2003 Mars Exploration Rover Mission: Technology and Experimental Results

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Abstract

This paper presents the technology and experimental results for high-precision landing-site mapping and rover localization developed for the ongoing 2003 Mars Exploration Rover (MER) mission. This technology is based on the bundle adjustment of an image network formed by Pancam, Navcam, and Hazcam stereo images.

A systematic method has been developed to efficiently build an image network through automatic tie point selection. This tie point selection method consists of five steps: interest point extraction, interest point matching, parallax verification, graph consistency verification, and, finally, tie point selection with gridding. In matching interest points between adjacent stereo pairs, a rough DEM is generated to predict the location of conjugate points and to limit the search range. In cases where there are no identifiable features or where the rover images are taken from opposite directions, a small number of manual tie points (usually less than 10 percent of the total number) are employed. In addition, the image network will be linked to orbital MOC NA images and the MOLA DTM through distinct landmarks. Thus the landing-site local coordinate system can be tied to the Mars body-fixed reference system. To facilitate the link between orbital and surface images at the two MER landing sites (Gusev and Meridiani), we have performed pre-landing analyses based on orbital data that include landmark identification, 3D landmark visualization, and visibility mapping.

An integrated bundle adjustment is developed and applied to the image network in order to improve accuracy of the position and orientation of the images as well as the ground location of feature points. An incremental bundle adjustment method is also developed to fulfill rover localization in real time (within a sol) or near-real time (sol by sol). Our experiments using Earth-based field test data and Mars (MPF) mission data have demonstrated that a relative localization accuracy of 1% to 0.1% of the traversing distance from the landing center can be achieved. In addition, we have shown that high-precision landing-site topographic mapping products (including seamless panoramic image mosaics, DTMs, and orthoimages) can be generated automatically.

Landing-site mapping and rover localization results using MER images gathered after the two rovers land on Mars in January 2004 will be presented at the conference.

Key Words: photogrammetry, extraterrestrial mapping, adjustment, matching, DTM, orthoimage.