Precision Photogrammetric Modeling of LROC NAC Cameras and Topographic Products. R. Li[1], W. Wang[1], S. He[1], J.W. Hwangbo[1], Y. Chen[1], P. Tang[1], X. Meng[1], Y. Choung[1], J. Lawver[1], P. Thomas[2], M. Robinson[3], M. Rosiek[4], and the LROC Team. [1]Mapping and GIS Laboratory, CEEGS, The Ohio State University, 470 Hitchcock Hall, 2070 Neil Avenue, Columbus, OH 43210-1275, li.282@osu.edu. [2]Cornell University. [3]Arizona State University. [4]U.S. Geological Survey.

Introduction: High-resolution imagery (0.5 to 2.0 m/pixel) collected by the Lunar Reconnaissance Orbiter (LRO) Narrow-Angle Cameras (NACs) [1] offers new opportunities for high-precision 3-D topographic mapping of the lunar surface while presenting unique challenges in precision photogrammetric modeling of the cameras. In the nominal phase of the mission, LRO has an average altitude of about 50km [2][8]. Images taken from two cross-track orbits over a lunar surface region forms a stereo image pair through a slew angle mechanism for generating a DEM (Figure 1) [3][6]. The overall process of obtaining 3-D mapping products (Figure 2) from such stereo image pairs consist of three major steps. First, we obtain the geometric parameters depicting the stereo imaging geometry of NACs, including the interior orientation (IO) and exterior orientation (EO) parameters of NACs, relative alignment (boresight parameters) between two NACs, and improve their accuracy through boresight calibration and bundle adjustment. Second, we extract and match image features from the stereo pairs. Last, we use these geometric parameters and matched image features to reconstruct 3-D lunar terrain points and produce a DEM and relative topographic products of the region.

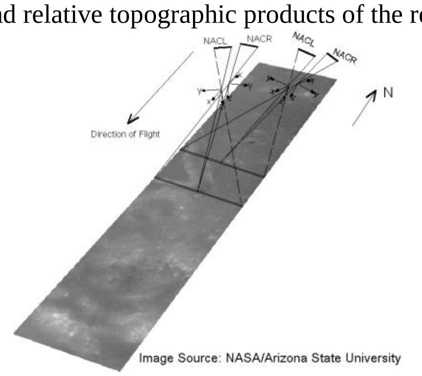

Figure 1. LROC stereo image simulation

This paper mainly focuses on obtaining and improving boresight parameters and EO parameters of cameras. Although these parameters are available or can be derived from the LRO SPICE kernel [4], in recent work we have used SPICE-based values as initial values and improved the boresight parameters and EO parameters substantially for DEM degradation. It was proven that it is critical to obtain high quality topographic products by achieving precision boresight calibration [2] and bundle adjustment [2][5].

Boresight Calibration: Boresight parameters describe the relative alignment between two NAC frames. Lack of precision in these parameters can cause inconsistencies between two NACs. Based on an analytical model of the transformations between the two NAC frames, we developed an algorithm to compute highly accurate boresight parameters based on least-squares solution of the three orientation angles between the two NACs. Analysis of residuals [7] and comparison of DEMs generated before and after boresight calibration have indicated that our boresight calibration algorithm is effective.

Bundle Adjustment: Bundle adjustment is used to improve the accuracy of the EO parameters of the stereo imagery. Being push-broom sensors, the positions and orientations of the NACs are time-dependent; therefore polynomial functions with time as a parameter were adapted to model the EO parameters [5]. By minimizing observation inconsistencies, least-squares analysis was able to adjust polynomial coefficients (including camera positions and orientations) iteratively during the bundle adjustment. After adjustment, the residuals of the observations were reduced from tens of pixels to a sub-pixel level.

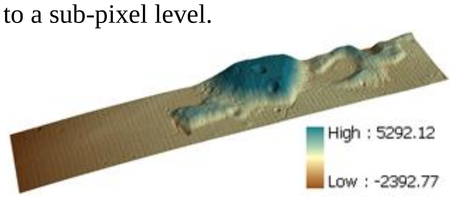

Figure 2. 3-D view of DEM from LRO stereo pairs.

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