Automatic DEM Generation from CE-1's CCD Stereo Camera Images. J.J.Liu, X. Ren, L. L. Mu, B. C. Zhao, B. Xiangli, J. F. Yang, Y. L. Zou, H. B. Zhang, C. LU, J. Z. Liu, W. Zuo, Y. Su, W. B. Wen, W. Bian, X. D. Zou, C.L.Li., National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, PR China, Correspondence(liujj@bao.ac.cn).

Introduction: The CCD Stereo Camera is one of the most important payloads aboard on the lunar orbiter Chang'E-1 (Ab., CE-1, the Chinese First Lunar Explorer). It utilizes the linear pushbroom imagery technique to capture stereo digital image triplets in along-trip mode from three view angles (forward, nadir and backward). The CCD was a frame transfer device which allowed four gain states (1,1.5, 3 and 3.5). The exposure times could vary in 3.2,7,20 and 84 ms depending on gain state and solar illumination. The spectrum of the CCD ranges from 500nm to 750 nm. The view field of the CCD camerawas 17 x 34 degrees, equivalent to a cross-track width of about 60 km at a nominal altitude of 200 km.The spatial resolution of the image is 120 m/pixel. Along scanning direction, we uses the 11th,512nd and 1013rd CCD line pixel as the forward, nadir and backward image. It means that three view angles of images for an object could be obtained near-simultaneously. The main scientific goal of the imaging system is to acquire 3D-images of lunar surface between 70S and 70N. The acquired images will be used for DEM and orhophoto image generation.In the scan direction, the image overlap ratio is about 41% on the equator.

Methods: Unlike frame-based aerial photography, where all pixels in a image are exposed simultaneously and therefore have only one group exterior orientation parameters, for the CE-1 stereo camera, three images from different view angles could be obtained for an objects of the lunar surface, each of which was collected in a pushbroom style at a different instant of time. Therefore, there is, in principle, a different set of values for the six exterior orientation parameters for each scan line. This paper describes the process of the CCD stereo camera images acquired, the configuration of the imaging system, the camera sensor model, the camera trajectory model and the EFP photogrammetric triangulation algorithm.

The sensor model is basic equations of the EFP photogrammetric triangulation. The trajectory model will be used to calculate the approximate 6 exterior orientation parameters for each scan line. We selected the EFP bundle-block adjustment as the main photogrammetric triangulation algorithm for the three directions of stereo images to calculate the 6 exterior orientation parameters of each scan line, and coordinates (including both plane and height coordinates) of the lunar surface object. Wang Ren-Xiang, 1992 developed a method of the EFP photogrammetric triangulation for the Three-Line-Scanner photogrammetry. This method is based on the collinearity equations and the exterior orientation parameters are determined by the EFP time, which are introduced at certain time intervals.

Results: Then, based on the EFP theory, this article give a photogrammetric processing scheme for the camera images(see Figure 1), mainly including EFP bundle-block adjustment, DEM and orthophoto generation. The DEM grid size is up to 500m. The pixel resolution is up to 150m, and the planar positioning accuracy is about 370m. Figure 2 shows an example of DEM and orthophoto data generated from the camera stereo images using EFP algorithm.

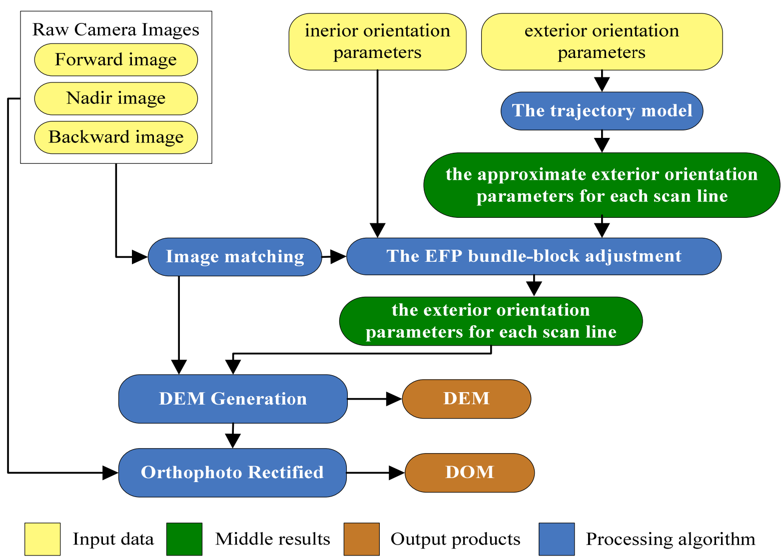

FIGURE 1. Flowchart of the photogrammetric processing scheme for the CCD Stereo Camera images.

References:

[1]Derenyi E.E., "An Exploratory Investigation Concerning the Relative Orientation of Continuous Strip Imagery", Ph.D. Thesis, The University of New Brunswich, 1970.

[2]Konecny G., "Höchauflsende Fernerkundungssensoren für kartographische Anwendungen in Entwichklungsländern",Zeitschrift für Photogrammetrie und Fernerkundung, Volume 64, No.2,pp.39-52,1996.

[3]Ebner, H., Kornus, W., Ohlhof, T., 1992. A Simulation Study on Point Determination for The MOMS-02/D2 Space Project Using an Extended Functional Model. IAPRS, Vol. 29, Part B4,Washington, D. C., pp. 458-464

[4]Fraser, C., S., Shao, J., 1996. Exterior Orientation Determination of MOMS-02 Three-Line Imagery: Experiences with the Australian Test Field Data. IAPRS, Vol. 31, Part B3, Vienna, pp.207-214

[5]Gruen, A., Zhang, L., Sensor Modeling for Aerial Mobile Mapping with Three-Line-Scanner (TLS) Imagery. ISPRS, 2002, Vol. 34, pp. 139-146.

[6]Gruen, A., Zhang L., 2002b: Automatic DTM Generation from Three-Line-Scanner (TLS) images. IAPRS, Vol. 34, Part 2A, Graz, Austria, pp. 131-137

[7]Heipke, C., Kornus, W., Pfannenstein, A., 1996, The Evaluation of MEOSS Airborne 3-Line Scanner Imagery - Processing Chain and Results. Photogrammetric Engineering and Remote Sensing, Vol 62, March, pp. 293-299.

[8]Hofman O., Hofmann M. and MeiBner D., "Ein Modulares, Opto-elektronisches, Multispektrales Satellitenbildaufnahme-System(MOMS) von MBB", XIV.ISP Congress, Comm.I, PP.42-49, Hamburg, 1980.

[9]Müller F., Hofmann O., Kaltenecher A. (1994): Digital Photogrammetric Assembly(DPS) point determination using airborne three-line camera imagery: practical results. Int.Arch. of Photogrammetry and Remote Sensing 30(3/2), 592-598.

[10]Murai S., Matsumoto Y., Li X. (1995): Stereoscopic imagery with an airborne 3-line scanner(TLS); Int. Arch. Of Photogrammetry and Remote Sensing 30(5W1), 20-25.

[11]Neukum G., Oberst J., Schwarz G., Flohrer J., Sebastian I., Jaumann R., Hoffmann H., Carsenty U., Eichentopf K., Pischel R.(1995): The Multiple Line Scanner Camera Experiment for the Russian mars96 Mission: Status Report and Prospects for the Future; in: Photogrammetric Week'95, edited by D. Fritsch and D. Hobbie, Wichmann, Karlsruhe,45-61.

[12]Ohlhof,T., Local, Regional and Global Point Determination Using Three-line Imagery and Orbital Constraints, XVIII ISPRS Congress, 1996, S.597-603.

[13]Samdai R., Bürwald W. (1994): A three-line wide-angle CCD stereo camera for Mars-94 mission; Int. Arch. Of Photogrammetry and Remote Sensing 30(1), 82-86.

[14]Rosiek, M. R., Kirk, R., Howington-Kraus, E., Digital Elevation Models Derived from Small Format Lunar Images, ASPRS 2000.

[15]Wang Ren-Xiang, Processing of line imagery photogrammetry Aerial triangulation(1), Science and Technology of Surveying and Mapping, 2001,Vol.26,p.1-6.

[16]Wang Ren-Xiang, Processing of line imagery photogrammetry Aerial triangulation(2), Science and Technology of Surveying and Mapping, 2002,Vol.26,p.1-7.

[17]Wiedemann C., Tang T., Ohlhof T., "A New Matching Approach for Three-Line Scanner Imagery". In: XVIII ISPRS Congress, Spatial Information from Images, Proceedings, Wien, July 9-19, 1996, Vol. XXXI, Part B3, Com.III, S.940-945.

Acknowledgments: The authors would like to thank Xi'an Research Institute of Surveying and Mapping and Xi'an Institute of Optics and Precision Mechanics of Chinese Academy of Sciences for their technique support.

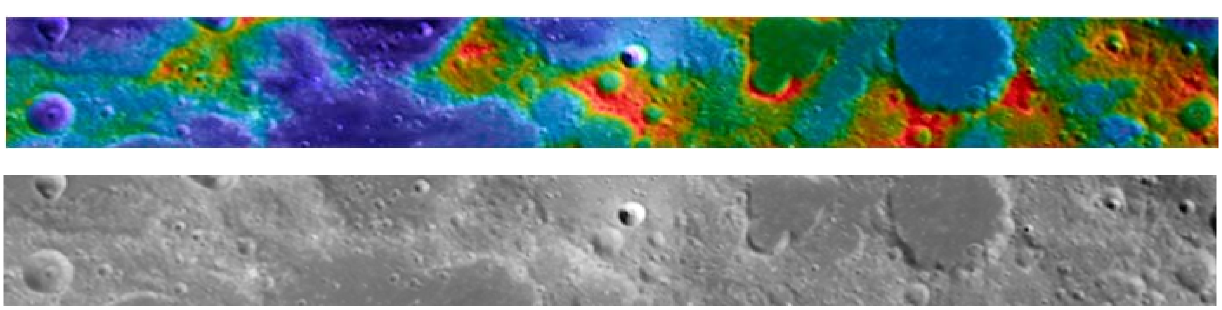

FIGURE 2. DEM and DOM Generated from the CCD Stereo Camera Images.