Alignment and Ortho-rectification of Lunar Surface Image using the NASA Ames Stereo Pipeline. S. H. Moon[1] and H. L. Choi[2], Department of Aerospace Engineering, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, 34141, Daejeon, Republic of Korea ([1]shmoon@lics.kaist.ac.kr, [2]hanlimc@lics.kaist.ac.kr).

Introduction: The Digital Elevation Model (DEM) of planetary surface is generated using stereo image pair. To generate the good 3D surface model, the conditions (viewing angle, illumination, sun position and etc.) of the image pair are needed to be similar. Significant differences in these conditions between these image pair can induce the feature matching error and that cause artifact of the stereo product. Because of these requirements, if there's a shaded or shadowed region in both image pair, that region remains as a blank in the stereo DEM. If the map-projected image data from the different light source condition exists and the shaded region in stereo image pair is seen in that image, surface information can be restored using a Shape from Shading (SfS) or photometric stereo method [1, 2].

In this paper, the ortho-rectification and alignment of a lunar surface image from the Lunar Reconnaissance Orbiter Camera (LROC) Experimental Data Record (EDR) data using Ames Stereo Pipeline (ASP) is outlined [3 - 5].

Methodology: It is described to generate the stereo DEM and ortho-rectified image dataset. The overall data flow of explained this chapter is shown in Figure 1.

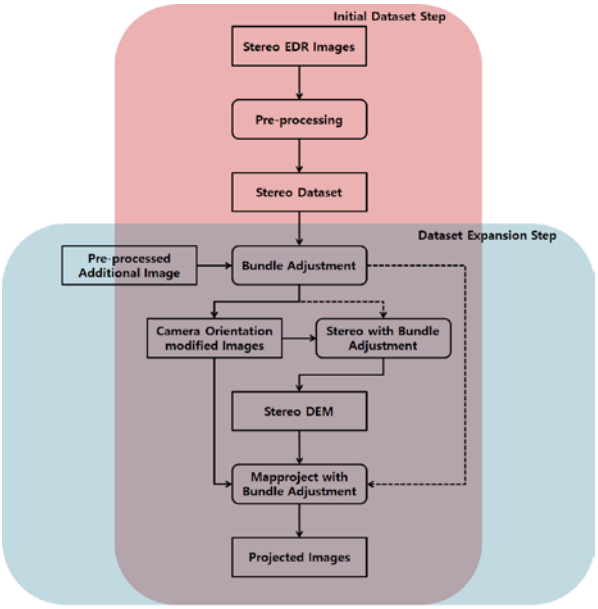

Figure 1: Flowchart of Overall Method

Initial Dataset Step. The methodology of constructing stereo DEM is explained in initial dataset step. In pre-processing, lronac2isis, spiceinit, lronaccal and lronacecho function in United States Geology Survey (USGS) Integrated Software for Imagers and Spectrometers 3 (ISIS3) is used for converting data format, adding SPICE kernel, photometric calibration and removing echo effects in a NAC image data. Because the size of the original image pair is large to process in a trial stage, it is needed to be resized using crop. In later, the other images will be map-projected on the stereo DEM from this step, so those images have to cover the region in DEM. Then, the bundle adjustment is operated with cropped image data. In this process, the camera orientation is modified based on extracted feature point dataset in the stereo image pair. Then, stereo DEM is constructed using a stereo function in ASP. To handle the camera orientation error, the modified camera orientation using bundle adjustment process is used in the stereo process. The output of stereo is transformed using the point2dem function in ASP. The ortho-rectification of the stereo image pair is performed using the mapproject function in ISIS3. The modified camera orientation using bundle adjustment process is needed again in this process to reduce the camera orientation error.

Dataset Expansion Step. In dataset expansion step, the other images are map-projected onto the stereo DEM generated the previous step. At first, the other images need to be pre-processed like in the previous step. The images in this process are needed to be cropped similar to image size used to generate DEM, too. The images will be map-projected onto the stereo DEM, so the images have to be cropped including the region of stereo DEM. Then, the bundle adjustment process is performed to modify camera orientation error of all images to be map-projected. The important thing is that the image condition of each image can very different, it can influence the performance of bundle adjustment. So, it's better to input an image similar to the stereo image pair than other images and try bundle adjustment several times one-by-one. After bundle adjustment step of additional images, the camera orientation of stereo image pair is also changed, it is needed to generate the stereo DEM with updated camera orientation of stereo image pair. Then, additional images can be ortho-rectified using the mapproject function with updated camera orientation of each image.

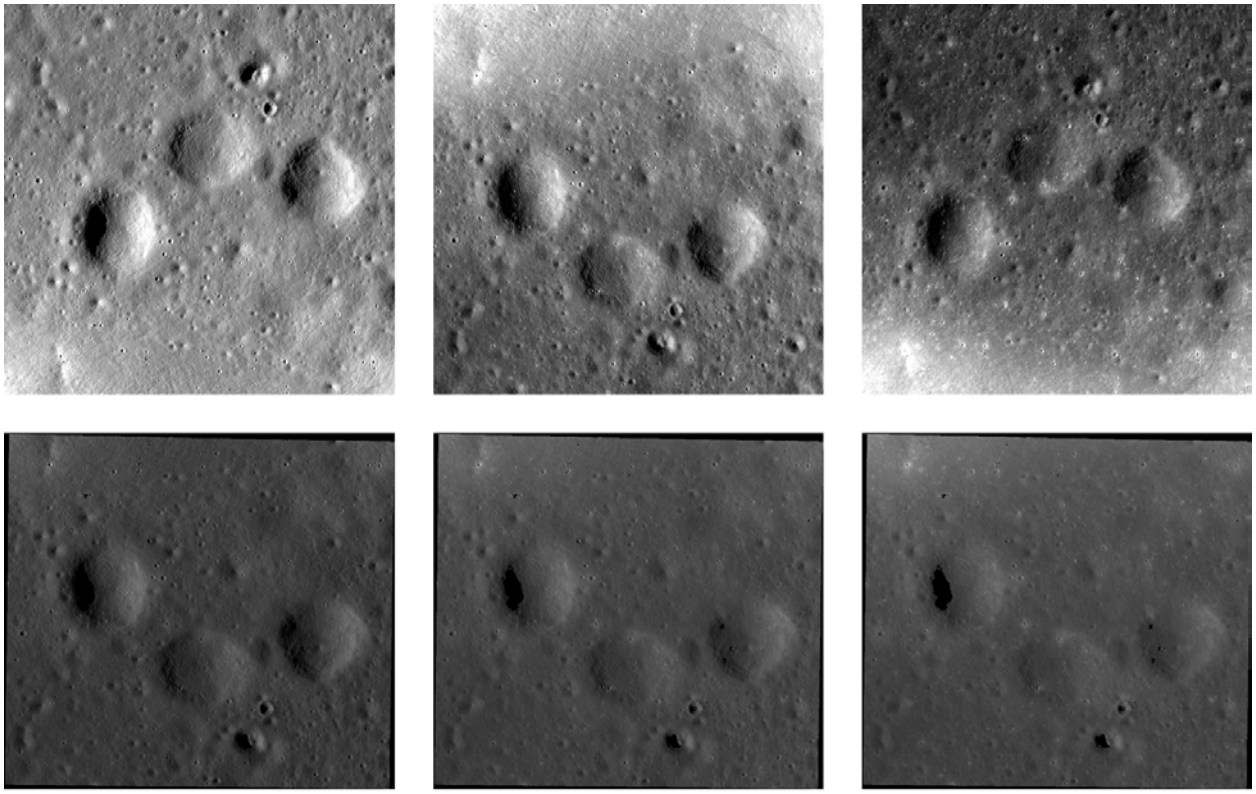

Figure 2: Cropped Apollo 17 Landing Site Image (top) and the Ortho-rectified Image (bottom) of M180966380L (left), M104318871R (middle) and M183325253R (right)

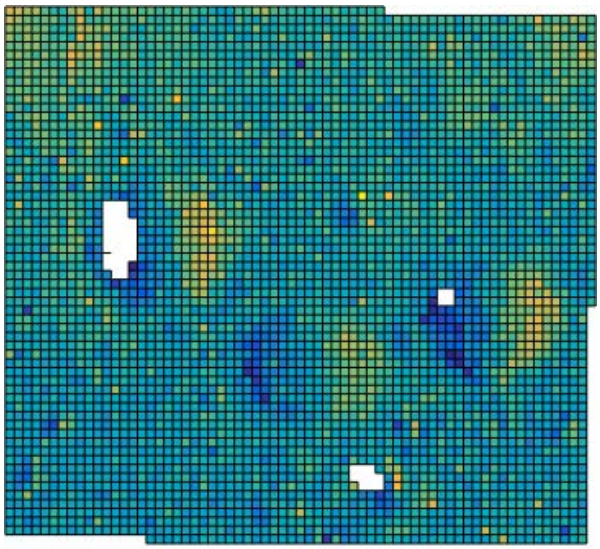

Figure 3: Blank in ortho-rectified image of M180966380L

Results: The LROC EDR data, M180966380L, M104318871R and M183325253R are used for this simulation. the stereo DEM is generated using M180966380L and M104318871R in initial dataset step. the cropped terrain size is 2000 × 2000 pixels at 1.3m/pixel, latitude 20.2470°N and longitude 30.8163°E. Then, M183325253R is added in dataset expansion step. The cropped images and ortho-rectified images are shown in Figure 2. The common black part of each image is blank which is induced from a stereo process, Figure 3 shows the position of blank.

Future Work: To generate the accurate surface normal map and albedo map, the ortho-rectified image dataset with various illumination conditions is needed to be constructed.

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