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The reconstruction of digital terrain model using panoramic camera images of Chang'E-3

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Abstract

The most direct and effective way of understanding the planetary topography and morphology is to build the accurate 3D planetary terrain model. Stereo images taken by the two panoramic cameras (PCAM), which were installed on the recently launched Change'E-3 rover, can be an optimal data source to assess the lunar landscape around the rover. This paper proposed a fast and efficient workflow to real-timely reconstruct the high-resolution 3D lunar terrain model, including the Digital Elevation Model (DEM) and Digital Orthophoto Map (DOM), using the PCAM stereo images. We found that the residual errors of coordinates in the adjacent images of the mosaiced DOM were within 2 pixels, and the distance deviation from the topographic data generated from the decent camera images was small. Thus, we concluded that this terrain model could satisfy the needs of identifying exploration targets and planning the rover traverse routes.

1. Introduction

As china's first lunar surface exploration mission carrying a lander and a rover, Chang'E-3 successfully descended on the northwestern Mare Imbrium at 19.51°W, 44.12°N on 14 December, 2013, and then started the exploration mission. The PCAM mounted on the rover mast, are one of the rover's major scientific payloads. Table.1 shows the information of PCAM's key parameters [1].

Table 1: Key parameters of the PCAM

Parameter	Parameter value
wavelength	visible
imaging mode	color or pan
imaging distance(m)	3～∞
image size	2352×1728
pixel resolution	7.4um
FOV(°)	19.7°×14.5°
Teo-in	1°

Under most circumstances, the PCAM can acquire 56 image pairs of the surrounding terrain at each observation site, and the final digital terrain model was built by mosaicing all the adjacent image pairs.

2.Data processing

The procedure of image processing mainly involves the calculation of exterior orientation elements, the stereo image matching, 3D coordinates calculation, elevation interpolation, ortho-rectification, and panorama mosaic [2]. The working flow is shown as Figure 1.

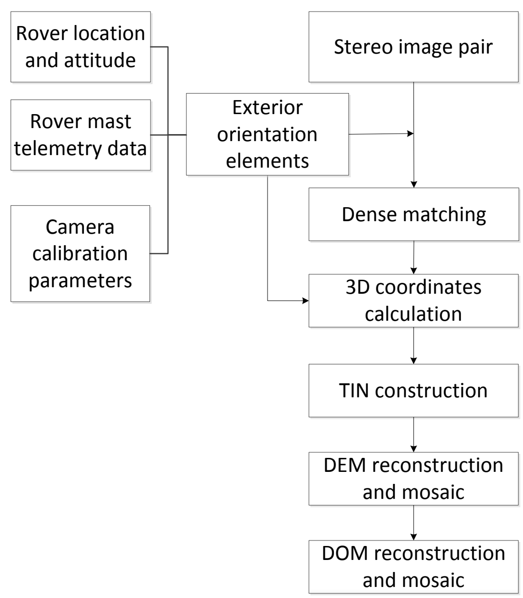

Figure 1: Diagram of data processing flow

3. Result and analysis

Considering both computational efficiency of real-time process and the need of detailed terrain depiction, we set the resolution of final terrain products as 0.02 m. This resolution guarantees the clear representation of the main lunar surface features for the determination of the rover traverse routes, and it can also meet the time requirement that is needed for the accomplishment of the current site data process and route planning for the next site within an hour. The 3D Digital Terrain Models with 0.02 m resolution for one site is shown in Figure 2 as an illustration.

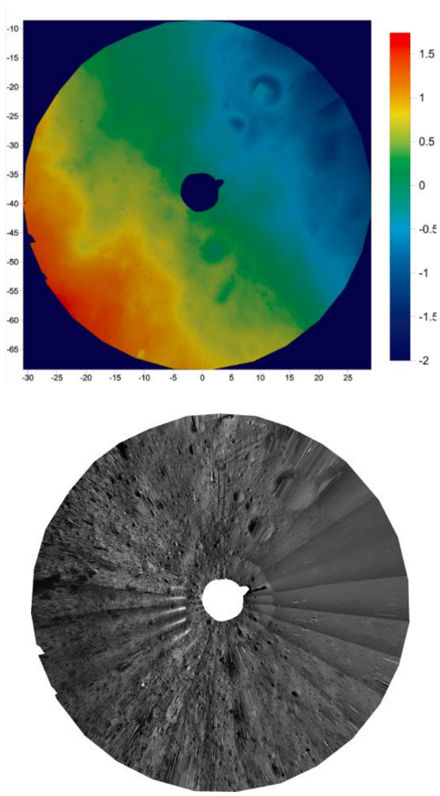

Figure 2: DEM and DOM of a site

In order to verify the DOM products, we chose several pairs of corresponding points in the overlap region of two adjacent images, and calculated their coordinate residual error. The maximum error in X direction is -0.02 m, and -0.03 m in Y direction. Both of them are within 2 pixels, which can be used in the mosaic of adjacent images.

In addition, to compare with the topographic data generated from the Chang'E-3 decent camera images, we selected several craters with clear features near the rover, and measured the distance from the rover to the crater centers in the decent image and DOM, separately. We supposed that the topographic data generated from the decent image is better.

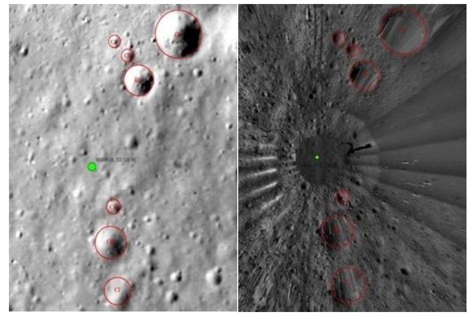

Figure 3: several craters nearby the Rover in the decent image and PCAM-DOM

As indicated from table 2, the absolute distance differences between the two images for all craters are within 1 m, with the maximum distance 0.73 m, and the absolute smallest distance 0.19 m. We also found that the relative error is also positively related with the distance from the point to the Rover. The further away from the rover, the larger the measurement error will be. The largest value of relative error to distance is resulted by C1, which is 4.3%.

Table 2: Distance from Rover to craters center in decent camera image and PCAM-DOM (m)

Craters number	Decent camera	PCAM-DOM	Diff	Diff/Dist (%)
C1	16.97	16.24	0.73	4.30
C2	15.67	15.21	0.46	2.94
C3	13.15	12.80	0.35	2.66
C4	21.27	20.55	0.72	3.39
C5	6.17	6.36	-0.19	3.08
C6	10.50	10.27	0.23	2.19
C7	16.96	17.63	-0.67	3.95

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References

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