In-flight Calibration of Mars Imaging Camera (MIC) on board NOZOMI, Mars exploring spacecraft

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http://www.planet-b.isas.ac.jp/MIC/MIC_j.html

Mars Imaging Camera (MIC) is the CCD camera on board NOZOMI the spacecraft launched on July 4th, 1998. MIC took the images to do in-flight calibration from the orbits around Earth and the Moon. The in-flight calibration of the sensitivity is done by (1)obtaining the absolute sensitivity of some CCD pixels, (2)calibrating the relative sensitivity of all pixels in each line, and then (3)leading to the absolute sensitivity of all pixels. For the precise geometric correction, we have to know the pointing error derived from the spacecraft position, its attitude and the spin rate, and the information about the alternation of the distortion by the lens from the pre-flight calibration. The method is to compare the estimated position and the actual position in the image.

[Introduction]

Mars Imaging Camera (MIC) is the CCD camera on board NOZOMI the spacecraft launched on July 4th, 1998. It is general that the characteristics of the instrument changes from those determined by pre-flight calibration [1]. It is important to do the in-flight calibration in the space. MIC took the images of Earth, moon and Jupiter to do such calibration from the orbits around Earth and the Moon until December 19, 1998.

[Calibration of Sensitivity]

MIC has three CCD lines (3x2560 pixels) with the visible color filters; 440-480 nm, 520-580 nm, 630-680 nm. The signal is digitized to 8 bit with about 20 DN (data number) of the offset level. Since the instrument has no own calibration target, the in-flight calibration of the sensitivity is done by (1)obtaining the absolute sensitivity of some CCD pixels, (2)calibrating the relative sensitivity of all pixels in each line, and then (3)leading to the absolute sensitivity of all pixels from the combination of (1) and (2).

The method to know the absolute sensitivity in flight is to detect the light source whose intensity is already known. Two light sources have been detected. First is the areas on the lunar surface where Shorthill et al. [2] observed by a telescope with the several phase angles. MIC took the images of these areas at the lunar-flybys, so that these data will be available for calibrating the absolute sensitivity. The range of wavelength used in this ground based observation is similar to that of the MIC green filter. We calibrate the red or blue bands referring to the color images taken by Clementine or the other ground-based observations. Second, MIC imaged Jupiter with three color bands. These data will be also available for the calibration of MIC.

The relative sensitivity of all pixels in each array including the vignetting is checked by comparing the signal of each pixel corresponding to the same intensity of incident light. MIC took the images of the same areas on the surface of the Moon with several pixels. They are useful for the calibration of the relative sensitivity. We cannot distinguish the vignetting from the uneven sensitivity of each pixels. However, it can be said that the relative sensitivity is greatly influenced by the vignetting; the intensity at its edge is known to be about 20% of that at the center from the pre-flight calibration.

The dark level data and its fluctuation were acquired by taking uncompressed images of the space. The dark level has not been changed significantly.

[Geometric Correction]

NOZOMI is a spin stabilized spacecraft, and MIC scans the azimuth direction (orthogonal to the axis) to take two-dimensional images. For the precise geometric correction, we have to know the pointing error derived from the spacecraft position, its attitude and the spin rate, and the information about the alternation of the distortion by the lens from the pre-flight calibration. The method is to compare the estimated position and the actual position in the image. We use the images taken in the center of the FOV to estimate the pointing error especially, because the distortion at the center of the FOV is the smallest.

We will explain these calibrations in this presentation.

[Reference]
[1] Helfenstein, P., J. Veverka, et al.,
"Galileo Photometry of Asteroid 951 Gaspra"
ICARUS 107, 37-60, 1994

[2] Shorthill, R. W., J.M. Sarri, et al.,
"Photometric Properties of Selected Lunar Features"
NASA Contractor Report CR-1429, 1969