THE INFLUENCE ON IMAGE QUALITY UNDER RELATIVE CALIBRATION ACCURACY

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Commission I, SS-4

KEY WORDS: accuracy, analysis, calibration, imagery, method, pushbroom, remote sensing,

ABSTRACT:

Strips can be seen in raw remote sensing images of CCD camera. The object of relative radiometric calibration is to eliminate them. This paper discusses the influence on image quality under different calibration accuracy. The laboratory radiometric calibration data of the China Brazil Earth Resources Satellite (CBERS) 02B CCD camera were used to analyse the data distribution which has been processed through the relative radiometric correction. A simulation method based on the statistic and analysis of the corrected data was found and used to simulate the corrected result after validating. The influence on image quality under different relative calibration accuracy was simulated with the method and Peak Signal to Noise Ratio (PSNR) was used to evaluate the results.

1 INTRODUCTION

Relative radiometric correction is the first step of the remote sensing image processing. The theory of normalized coefficients algorithm, two-point algorithm and least-squares algorithm are usually used in relative radiometric calibration. According to the relative linearity curve (the linearity between the output DN value and the expected DN value of a pixel), the appropriate algorithm is selected to calculate the calibration coefficients and correct the raw remote sensing image. By this way, the strips in the images are reduced. But they can't be eliminated absolutely because of the relative calibration error. The influence on image quality under different calibration accuracy was researched in this paper.

The process can be divided into three steps. Firstly, laboratory radiometric calibration data of CBERS 02B CCD camera were processed and the relative calibration coefficients were obtained. Secondly, the calibration coefficients were used to correct the calibration image and the distribution of the corrected data was analyzed. Finally, the influence on image quality under different relative calibration accuracy was simulated with Matlab.

2 ANALYSIS OF CBERS 02B CCD DATA

Original radiometric calibration data of CBERS 02B CCD camera were acquired by viewing an integrating semi-sphere in laboratory before the satellite was launched. These data are processed and analyzed in this section.

Taking the data process of Band B2 as an example. The relative linearity curve is linear by analyzing the data. So the linear least-squares algorithm is selected to calculate the relative calibration coefficients and correct the raw data. The corrected result of B2 is shown in Fig. 1.

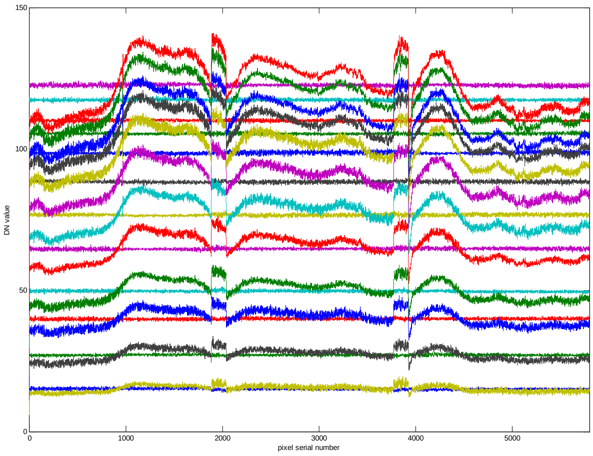

Fig.1. Corrected result of spectrum B2 data

After correction, the DN values varied in 2~3 and the standard deviation is less than 0.5 in a row. The result is good enough. The statistic histograms of the corrected data in all radiance levels are shown in Fig. 2.

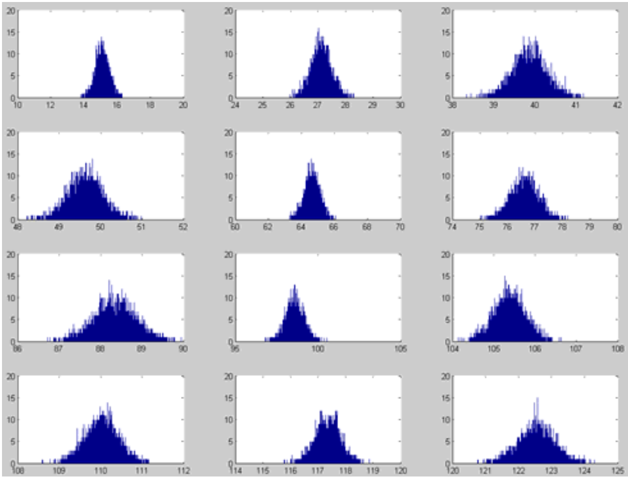

Fig.2. Distribution histograms of corrected data in B2

The dispersion of the collected calibration data done with relative radiometric correction is called the relative calibration accuracy. Equation 1 is used to calculate it.

$$RA = \frac{\sqrt{\dfrac{\sum_{j=1}^{n}(DN_j - \overline{DN})^2}{n-1}}}{\overline{DN}} \times 100\% \qquad (1)$$

The calibration results of CBERS 02B CCD data are listed in Table 1.

Radiance level	The average DN values after corrected	The relative calibration accuracy (%)
1	15.0582	2.78
2	27.0772	1.50
3	39.8562	1.13
4	49.6421	0.92
5	64.6399	0.74
6	76.6266	0.66
7	88.3551	0.58
8	98.5708	0.54
9	105.3885	0.41
10	110.0155	0.41
11	117.3167	0.40
12	122.5048	0.43

Table 1. Calibration results of B2

Judging from the histograms, the data follows the normal distribution. The χ^2 test is used to checkout whether the distribution followed the normal distribution and the result shown that it satisfied the test condition. So the corrected calibration data of CBERS 02B CCD camera obeys the normal distribution.

The object of relative calibration is to eliminate the nonuniformity of output DN values under the uniform input illumination. All output DN values should be the same after correction. But they can't be identical actually because of the calibration error. The calibration accuracy is about 2% now and the range of DN values is about 2~3. So the data in a row of the average DN for each pixel can be described nearly by normal distribution. The distribution of the corrected and expected data in all radiance levels is shown as Fig.3.

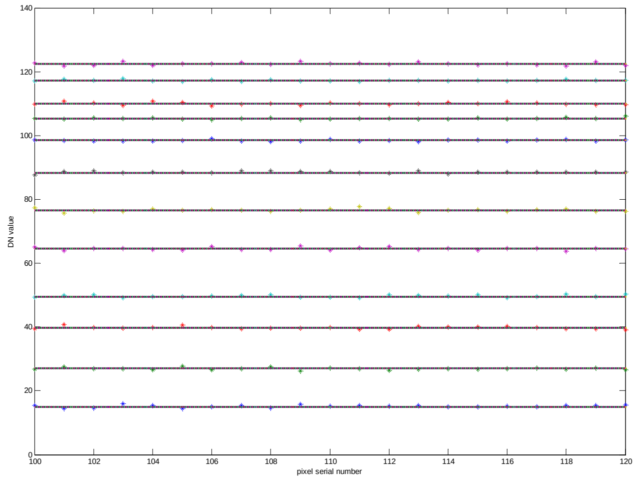

Fig.3. Distribution of the corrected and expected data

In this figure, the symbol '*' represents the corrected DN values and the lines correspond to the expected values in different radiance levels.

From this figure, it can be seen that the corrected DN values are around the expected values. Some are bigger and others are smaller. According to the least-squares method, this phenomenon is correct. There is no certain rule between the corrected DN values and the expected values. The relationship depends on the original output data of each pixel. At the same time, there is no fixed relationship of the corrected values between different pixels.

3 THE INFLUENCE ON IMAGE QUALITY UNDER DIFFERENT RELATIVE CALIBRATION ACCURACY

3.1 Simulation method

The difference between the ideal image (which is got in the situation that every pixel has the same output under the uniform incident radiance) and the actual image (which has been processed with relative correction) was simulated under different relative calibration accuracy in this paper. The results can be observed subjectively and evaluated by PSNR objectively.

According to the analysis of corrected CBERS 02B CCD data, the simulation method is as follows (assuming it is 8-bit quantified and the number of pixels is n). A) Generating a normal one-dimensional simulation coefficients array whose size is $1 \times n$ for every quantitative level, so the entire array's size is $256 \times n$. B) Looking for simulation coefficient according to the DN values and the pixel's position. C) The simulated image is generated by multiplying the simulation coefficients. It must be noted that the calibration accuracy in every radiance level should be set separately according to the user's requirement.

The Equation 2 is generated from Equation 1.

$$RA = \frac{\sqrt{\frac{\sum_{i=1}^{n}(DN_i - \overline{DN})^2}{n-1}}}{\overline{DN}} = \frac{\sqrt{\frac{\sum_{i=1}^{n}(kDN_i - k\overline{DN})^2}{n-1}}}{k\overline{DN}} \tag{2}$$

It means that the calibration accuracy of the corrected average row data is unchangeable no matter multiplying a constant or not, so a normal one-dimensional array whose mathematical expectation is 1 and standard deviation is the required calibration accuracy is generated. When a uniform image multiplies this array, the calibration accuracy is changeless. The two-dimensional simulation array is acquired by generating 256 one-dimensional arrays for all quantified levels.

If all quantified levels' calibration accuracy could be acquired, the actual image done with relative radiance correction can be simulated. In this paper, all levels' accuracy is set to be the same value as enough data about accuracy can't be gotten, so the simulation results are the worst under the specification. It is different from the actual situation that the calibration accuracy is different in different radiance level.

PSNR is used to evaluate the influence of calibration accuracy objectively. The image quality will be better if PSNR is higher.

3.2 Simulation program validation

If the incident light is uniform, all output DN values after correcting should be same in the ideal circumstances. However, they vary in 2~3 DN because of calibration error and the histograms obey normal distribution approximately. The relation between corrected and expected values is unfixed for a pixel in every radiance level. The simulation program was compiled based on the above analysis and the calibration results shown in Table 1 are used as inputs to validate the simulation method. The simulation results are shown in Fig.4 and Fig.5.

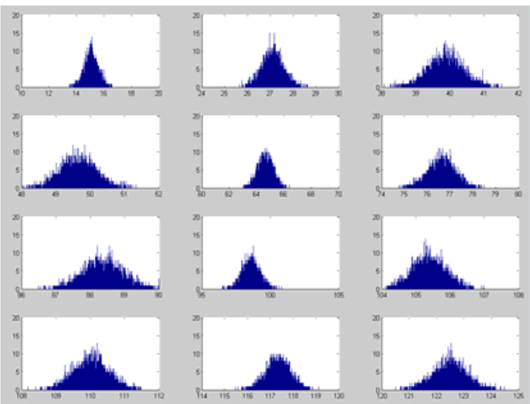

Fig.4. Simulation result in B2

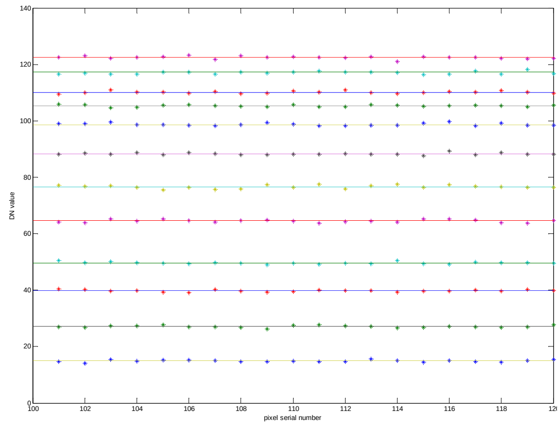

Fig.5. Simulation result in different level

The simulation results are consistent with the statistical results according to Fig. 2-5. The simulation program is proper.

3.3 The influence on image quality under relative calibration accuracy

Some common images are used as the ideal images. Fig. 6 is used as an input image to analyze the influence on image quality under different relative calibration accuracy. Its size is 512×512. After generating simulation array according to the input accuracy, the program checks up the simulation coefficient by pixel serial number and DN value in the image. The simulation results are acquired by multiplying the simulation coefficients. The simulation results in different accuracy are shown in Fig.7, 8, and 9.

Fig.6 Input image

Fig.7 Simulation result when the accuracy is 2%

Fig.8 Simulation result when the accuracy is 3%

Fig.9 Simulation result when the accuracy is 4%

The simulation has been done with other accuracy and the statistical results are shown in Table 2.

Relative calibration accuracy(%)	0.5	1	1.5	2	3	4
PSNR	50.0	44.3	40.9	38.5	35.0	32.5

Table 2. The influence on image quality under different calibration accuracy

The image is clear when the calibration accuracy is 2%. There are some strips in the homogeneous area of the image when the calibration accuracy is 3%, but it is not obvious. When the calibration accuracy is 4%, the strips in the homogeneous area are obvious.

Other images have also been used as the input images and the simulation results are nearly the same as the results in Table 2. PSNR can evaluate the influence properly. The original output DN values after being corrected are different slightly from the expected values because of the calibration error. The user can determine their requirement about relative calibration accuracy according to their acceptable DN distortion and the simulation results can be referenced.

4 SUMMARY

The influence on image quality under different relative calibration accuracy is acquired by simulation. Sometimes, an image processed with relative radiometric correction still has many strips. This phenomenon happens when the calibration coefficients are failed and it is not studied in this paper. In that case, the user should correct the raw images with other relative calibration coefficients again. The simulation results in this paper are acquired when the relative calibration and correction are both done properly.

REFERENCES

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