SHADOW EXTRACTION AND CORRECTION FROM QUICKBIRD IMAGES

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1. INTRODUCTION

Shadows in remote sensing images often result in problems for many applications such as land-cover classification, change detection, and damage detection in disasters. Due to these reasons, it is very useful if the radiance of shadow areas is corrected to the same radiance as shadow-free areas. There have been several researches on the detection and correction of shadow [1, 2]. But these methods have not been tested for various cases and the characteristics of shadows have not been so well investigated.

In this paper, a simple image pre-processing approach is proposed to correct the digital numbers (DNs) of shadowed areas in QuickBird (QB) images. First, the characteristics of radiance ratio (shadow/sunlit) in QB images are investigated by the radiance measurement and the effective spectral quantum efficiency of QB sensor. Then the relationship between the radiance ratio and the sun height is estimated. From a QB image, shadowed areas are extracted by an object-based method and the radiance ratio of shadow and sunlit areas in each band is calculated based on the sun height when the image was acquired. Finally, the method to correct the DN values of the shadowed areas is proposed using the radiance ratio and the DN values of shadow-free areas. A QB image of Tokyo, Japan, is introduced as an example.

2. CHARACTERISTICS OF RADIANCE RATIO FOR SHADOWED AND SUNLIT AREAS

In our previous paper, the measurement of spectral radiance of the sunlight was carried out in sunlit and shadowed areas [3]. Several characteristics of the radiance ratio (shadow/sunlit) have been detected. However, these characteristics can not be directly used for shadow correction from remote sensing images. In this study, the effective spectral quantum efficiency (QE) of the QuickBird (QB) sensor is introduced, and the radiance ratio in each band of a QB image can be calculated by expression 1).

$$R = \frac{\sum (I_{shadow} \times E)}{\sum E} / \frac{\sum (I_{sunlit} \times E)}{\sum E} \tag{1}$$

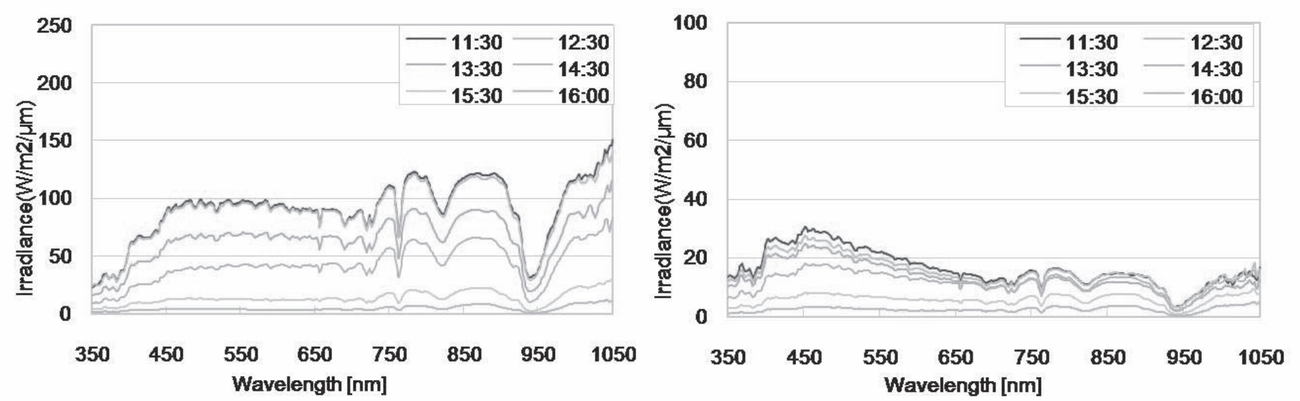

Figure 1. The measured radiance of a white plate on the rooftop of Chiba University, Japan on Dec. 4, 2008 in a sunlit area (left) and a light shadow (right).

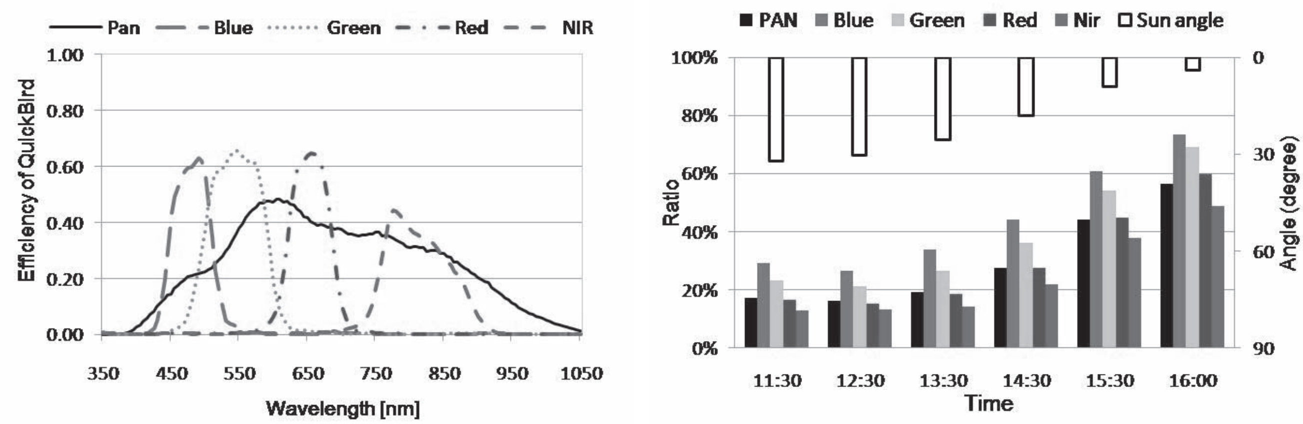

Figure 2. The effective spectral quantum efficiency (QE) of QuickBird sensor (left), and the ratio calculated from the results of the measurement and the QE (right).

where I is the measured irradiance of sunlight, and E is the QE of QB in the wavelength range from 350nm to 1050nm. Figure 1 shows the radiance of a white plate in a sunlit and a light shadow area, measured on December 4, 2008. Figure 2 (left) shows the QE of QB sensor, and (right) shows the ratio calculated in each band of QB images. The sun height (elevation) is also introduced to investigate the relationship with the ratio. It is observed that the radiance ratio of a shadow and a sunlit area increases as the sun height gets lower.

3. OBJECT-BASED SHADOW EXTRACTION AND CORRECTION

There have been several researches about shadow extraction from remote sensing images by pixel-based methods [3, 4]. However, shadowed areas cannot be completely extracted by the pixel-based methods, e.g. white roofs in shadowed areas cannot be extracted due to their high brightness values and dark vehicles in a sunlit area are extracted as in shadow due to their low brightness values. In this study, a QB image of the central Tokyo, Japan, shown in Figure 3 (left) is introduced to extract shadow areas by a object-based method of *Definiens* software.

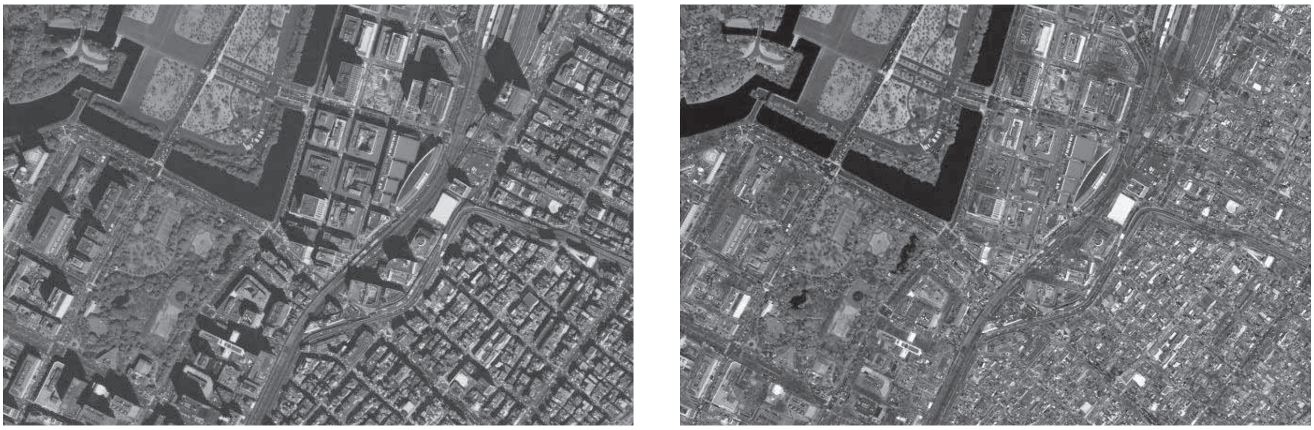

Figure 3. False color composite for the QuickBird image of Tokyo, Japan (left) and the shadow-corrected image (right).

The QB bundle product has a 0.6m resolution panchromatic (PAN) band and 2.4m resolution multi-spectral (MS) bands (R, G, B, and NIR), before the pan-sharpening process. First, the pixels in the QB image were grouped into objects depending on the brightness value of the PAN band with the scale parameter 20. The threshold value to extract shadowed areas was determined from the histogram of the PAN band DN values by visual inspection. Then the objects whose brightness values are smaller than the threshold were considered as in shadow. To improve the accuracy of shadow correction, the shadowed objects were classified into 3 classes as dark-shadow, main-shadow, and light-shadow. Then the objects with a area size less than 20 pixels are removed from shadow classes. Then the objects in the sunlight having a border line over 90% with shadow objects are classified as in shadow. In this approach, the errors occurred in the pixel-based extraction can be reduced.

In our previous paper [3], linear correction method by best fitting with sample datasets was proposed. Since the ratio of DN vales in a shadow and a sunlit area was calculated from the dataset, the accuracy depends on manual data selection. It is also time consuming to search the same material objects in shadowed and sunlit areas manually. In this paper, the ratio is calculated by the sun height. The QB image was acquired on March 20, 2008 at 10:48, the elevation of sun is 51.03 degree. Depending on the relationship estimated from the radiance measurement, the ratio *R* can be calculated in each band. Then the objects in the main-shadow class extracted are corrected by a linear expression. Since the influence of shadow darkness has been proved, the objects in dark-shadow and light-shadow classes are corrected with different ratios. In this shadow extraction approach, each object in dark-shadow or light-shadow class is given an index *In* from 0 to 1, showing the difference with the main-shadow class. The objects in the light-shadow class are corrected with the ratio *R*In*, and the objects in the dark-shadow class are corrected with the ratio *R*(1-In)*.

The result of shadow correction is shown in Figure 3 (right). Comparing with Figure 3 (left), shadows were mostly corrected. Finally, the unsupervised classification was conducted for the original and shadow-corrected

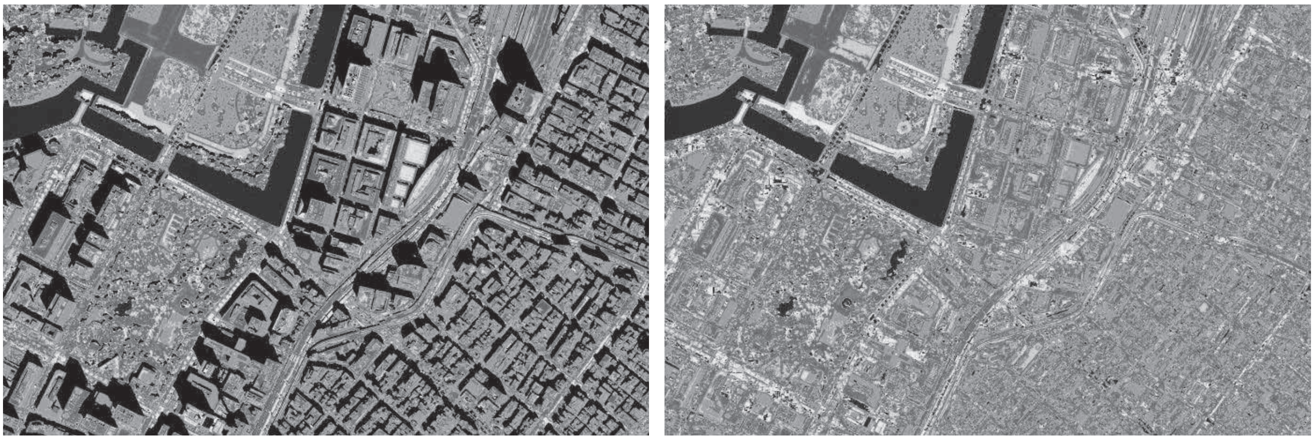

Figure 4. The result of unsupervised classification for the original image with 12 classes (left) and that for the corrected QB image with 10 classes (right) by K-means method .

images. The original image was classified into 12 classes, and the most of shadow areas are seen to be classified into two classes. The shadow-corrected image was classified into 10 classes. The results are seen to be successful.

4. CONCULSIONS

An object-based method was proposed to extract shadowed areas from QuickBird images, and the radiance radio estimated from the sun height was used to correct shadow. Using the area size and relationship with neighbor objects, the objects in shadow areas can be extracted successfully. Then shadow areas with 3 classes of darkness, are corrected with different ratios which calculated from the sun height by liner expression. A QuickBird image of Tokyo was then introduced and the effectiveness of the shadow correction method was demonstrated by visual inspection and by land-cover classification.

5. REFERENCES

[1] A. Abd-Elrahman, I. F. Shaker, A. K. Abdel-Gawad and A. Abdel-Wahab, "Enhancement of Cloud-Associated Shadow Areas in Satellite Image Using Wavelet Image Fusion", *World Applied Science Journal*, IDOSI Publications, Vol. 4, No. 6, pp. 363-370, 2008.

[2] K. Kouchi, and F. Yamazaki, "Characteristics of Tsunami-Affected Areas in Moderate-Resolution Satellite Images", *Transactions on Geoscience and Remote Sensing*, IEEE, Vol. 45, No. 6, pp.1650-1657, 2007.

[3] F. Yamazaki, W. Liu and M. Takasaki, "Characteristics of Shadow and Removal of its Effect for Remote Sensing Imagery", *Proceedings of the IEEE 2009 International Geoscience and Remote Sensing Symposium*, IEEE, CD-ROM, 4p, 2009.

[4] P. Sarabandi, F. Yamazaki, M. Matsuoka, A. Kiremidjian, "Shadow Detection and Radiometric Restoration in Satellite High Resolution Images", *Proceedings of the IEEE 2004 International Geoscience and Remote Sensing Symposium*, IEEE, CD-ROM, 4p, 2004.