Extraction of Cirrus Cloud and Its Shadow Based on HJ-1A/B Imagery

Yue Dai, Zhongshi Tang, Wenhao Ou, Kui Shao, and Yu Xin

3S Center, Tsinghua University, Beijing 100084, China

Abstract. A new method about the extraction of cirrus cloud and its shadow from multispectral imageries was proposed in this paper, which based on the reflection characteristics, shape and position relationships of cirrus cloud and its shadow. First, analyzed their reflection characteristics, and then used two thresholds to attain the general regions. Second, based on their shape and position relationships, used the dilation operator and image shift method in turn to attain their accurate regions. The new method was tested with the imagery of HJ-1A/B in Fuling Chongqing, and compared with the traditional methods was the best.

Keywords: Extraction of Cloud and Shadow, Imagery Processing, Environmental I Satellite Imagery.

1 Introduction

Usually in optical remote sensing imageries, the cirrus cloud (thick cloud as well) and its shadow form cloaks on the ground, which makes bad influence on the extraction of land surface information. The bad influence reflects in two aspects. Firstly, they make absolute photography blank under the cirrus cloud [1], so that reduce the amount of information in the imagery. Secondly, the color and grey-scale of the features in the imagery that surrounded by the cloud or its shadow would be affected, it makes their pixel characteristic different from the similar features'. China had launched Environment I Satellite (HJ-1A/B) in September, 2008, which load the CCD camera with four bands (blue, green, red and near infrared). The resolution of the satellite is 30 meters, and the capacities of widely imaging and four-day revisit make the imageries widely used in various field, such as environment protection, agriculture, land and water resources [2]. So it's necessary to remove the cirrus cloud and its shadow in the imagery for use in practice.

2 Methods

2.1 Image Characteristic of Cirrus Cloud and Its Shadow

Based on principles of remote sensing imaging, we can analysis the reflection characteristic and geometric characteristic of cirrus cloud and its shadow in the image.

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The cirrus cloud and its shadow differs a lot from other features in the aspect of reflection characteristic, their grey-scales in the imagery are very different. The cirrus cloud has so strong reflection that it shows very high brightness in every band image, and the shadow is completely opposite. Other features like water, plant, bare ground and constructions, they all show different brightness in each band image. One of cirrus cloud and its shadow's geometric characteristic is that they both can be described with big area, the 'big' means they may covers dozens of pixel in the image with resolution of 30 meters. Another important geometric characteristic is that the cirrus cloud and its shadow appear parallel in the image and have similar shapes, as the shadow is formed from the cirrus cloud [3].

2.2 Traditional Methods

We commonly set thresholds to extract the cirrus cloud and its shadow based on their reflection characteristic. After repeated test on satellite images of SPOT, IKONOS and Landsat, an empirical formula have been commonly used to get the thresholds T_{cloud} and T_{shadow} as follow [4]:

$$T_{cloud}=m+u \tag{1}$$

$$T_{shadow}=m-u \tag{2}$$

In the formula, m represents the mean value of the gray scale image, and u represents its standard deviation value. An improved method upon the threshold method is decision tree method, which set different thresholds in different bands to attain the accurate region step by step [5]. The shortage of threshold method is that its extracted region relies on the threshold so much that it always results in oversize or undersize. Another method takes the geometric characteristic into consideration, based on the thresholds extraction result and the assumption that cirrus cloud and its shadow can be described with a closed irregular curve, and then uses the dilation operator in mathematical morphology and contour tracking to extract the region [6]. This method is short for the detection of noise of other features in the origin extracted region of cirrus cloud and shadow, which may results in an inaccurate answer. To detect the noise, for the area of cirrus cloud is usually quite big, so someone thinks part of the extracted region that is composed with few pixel should be seen as noise and to be removed [7]. This detection method is good in that it can remove some construction and small water body features, but in the contrast, it may remove some cloud pixels from the cloud boundary.

2.3 New Methods

In this paper, an improved method about the extraction of cirrus cloud and its shadow is proposed, which based on the reflection characteristics, shape and position relationships of cirrus cloud and its shadow. First, analyze their reflection characteristics, and then use two thresholds to attain their binary images of the general regions. Second, use the dilation operator and image shift method with the extracted cloud based on their shape and position relationships. Then, get the accurate shadow from the intersection of the origin extracted shadow and the shifted cloud to get rid of other features. Last, use the dilation operator and reverse shift with the accurate shadow, and get the accurate cloud from the intersection of shadow and origin cloud.

3 Materials and Result

In this paper, the improved method is tested with the experimental data of a satellite imagery of HJ-1A on August 28, 2011. After layer stacking and radiometric correction process, the imagery in Fuling Chongqing is cropped. This image contains water body, city with constructions, mountain with plant and bare ground, and also contains two pieces of complete cirrus cloud and its shadow, which are on the lower right of the image, that probably makes the image suit for verifying the precision of extraction by improved method.

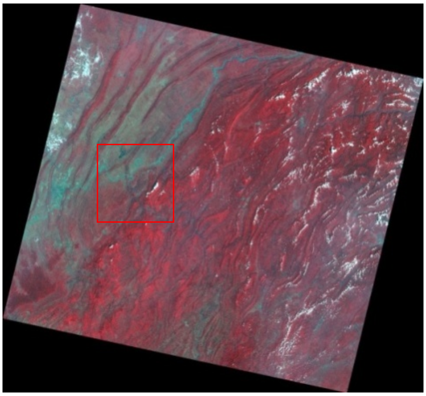

Fig. 1. Imagery of HJ-1A

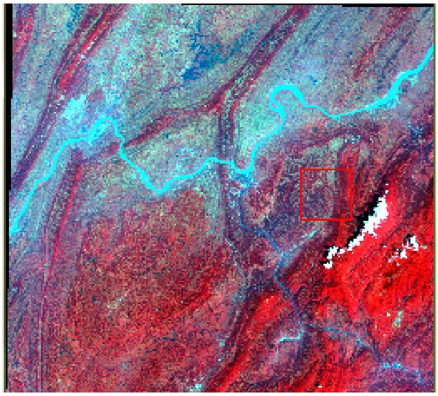

Fig. 2. Imagery in Fuling

Table 1. The Grey-scales of Features in Four Bands

Band		Cloud	Shadow	Water	Constructions	Plant	Bares
Band1	blue	4	1	2-3	3	1-2	3
Band2	green	4	1	2-3	2-3	1-2	3
Band3	red	4	1	3	2-3	1	3
Band4	near infrared	4	1	1	1	3	3

If the grey-scale is divided into four levels, 1 represents the darkest and 4 represents the brightest, the gray-scales of features in four bands are various as listed in Table 1. From the table we can see the grey-scales of features are similar in visible spectrums (blue, green, red), but are very different from the near infrared spectrum. In this paper, we multiply the 1, 2, 4 band to enlarge the grey-scale difference between features. In the new image, the gray-scales of features have changed as listed Table 2.

$$DN(b1b2b4)=DN(Band1)*DN(Band2)*DN(Band4) \tag{3}$$

Table 2. The Grey-scales of Features in Multiple Band

Band	Cloud	Shadow	Water	Constructions	Plant	Bares
B1*B2*B4	4	1	2-3	2-3	2-3	3

T_{cloud} can be used to extract the rough region of cirrus cloud which is calculated with Formula 1. Because the mean value is less than the deviation value, we get the T_{shadow} with Formula 2 from the image in which the rough cloud region has been removed. The extracted results are listed in Fig 3 and Fig 4. The result shows that the cirrus cloud is well extracted, but it still contains a little construction region as in Fig 5. And in the case of shadow, there is too much extra region of water or plant in the extracted result as in Fig 6.

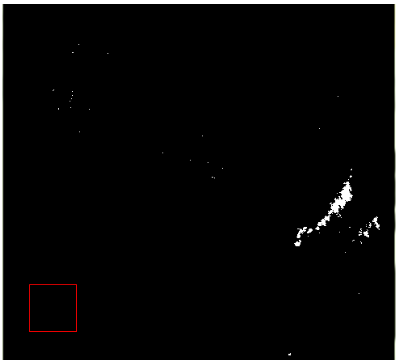

Fig. 3. The Extracted Result with T_{cloud}

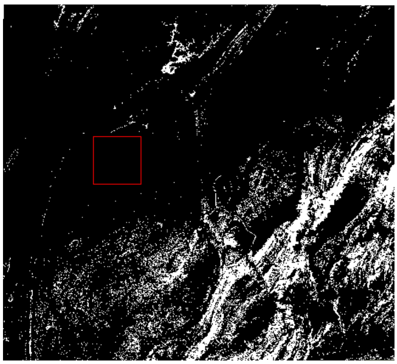

Fig. 4. The Extracted Result with T_{shadow}

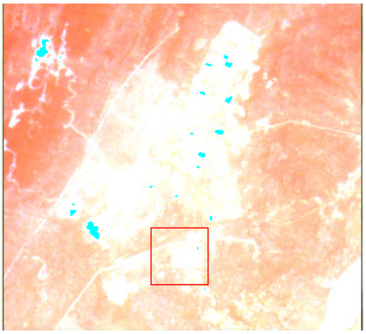

Fig. 5. Constructions in Cloud

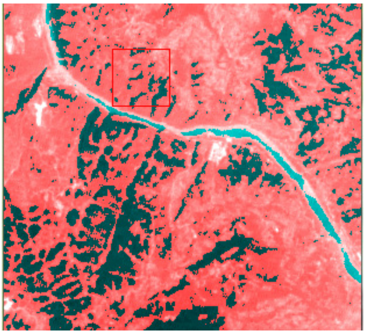

Fig. 6. Plant and Water in Shadow

For the extraction of cloud boundary usually is not complete, the next step is to use the dilation operator with 8-adjacent connection for six times. As the shadow is formed from cloud, the extracted cloud image is to be shifted to match the shadow image, and make the intersection of shifted cloud and shadow to attain the accurate shadow region as Fig 7. Then, dilate the shadow and shift it back to match the origin cloud to make the intersection and attain the accurate cloud region as Fig 8.

Fig 9 is the layer stacking result of cloud's binary image, shadow's binary image and band2. The result shows that the noise from other features has been removed from the extracted region.

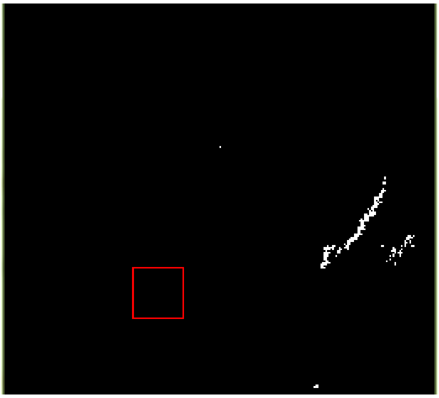

Fig. 7. Accurate Shadow

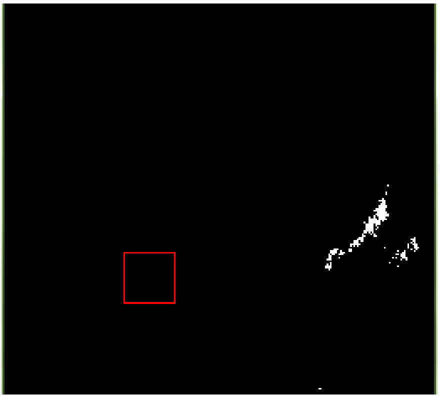

Fig. 8. Accurate Cloud

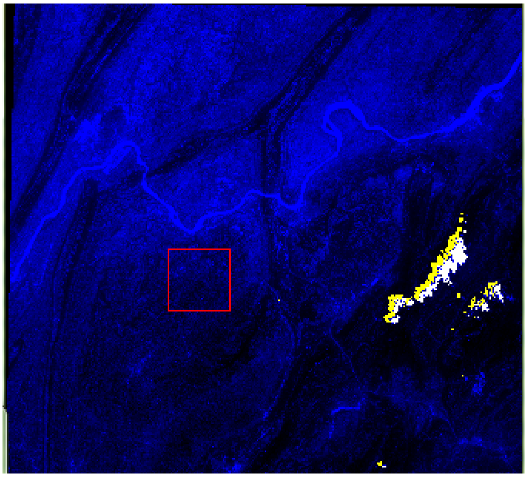

Fig. 9. RGB(Shadow,Cloud,Band3)

4 Conclusion

The cirrus cloud and its shadow make bad influence on the extraction of land surface information from optical remote sensing imagery. The traditional method to extract cloud and shadow takes only their reflection characteristic into consideration so that the result may contains many other features. The improve method also considers their geometric characteristic based on the traditional method. It effectively has the noise from other features removed from the extracted region so that greatly improve extraction accuracy of the cirrus cloud and its shadow information.

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References

1. Zhu, S.-L., Zhu, B.-S., Sha, C.-S., et al.: Removal process of cloud from IKONOS imagery with auxiliary image.利用辅助影像进行IKONOS图像的去云处理. Geomatic Science and Engineering 24(4), 25–28 (2004)
2. Wu, G.-Z., Xu, W., Bai, Z.-G.: Comprehensive analysis for the application of EnvironmentalI Satellite. 环境一号卫星应用成效综合分析. China Environmental Science 32(S1), 1–5 (2012)
3. Huang, Y.-J., Wang, S.-G., Liu, J.-Y., Chen, D.: Research on Removing Cloud to the Remote Sensing Images. 遥感图像去云算法研究. Chinese Journal of Scientific Instrument 24(4), 490–491 (2003)

4. Zhang, Y.-S., Dai, C.-G., Zhang, Y.-B., et al.: Information fusion of space-based multiple remote sensing sources. 天基多源遥感信息融合. Science Press, Beijing (2005)
5. Zheng, X.-Y., Zhang, Y.-H., Liu, W.-S.: A study of theremoval of shadow of cloud in the process of water body extraction in Zhalong wetland.扎龙湿地水体遥感提取过程中云阴影去除方法研究. Wetland Science 8(1), 21–27 (2010)
6. Dong, B.-G., Qin, Z.-Y., Yang, H.-Z., Li, H.: Study on Method of Automatically Extracting Cirrus Clouds andShadows in Remote Sensing Images,遥感图像上朵云及阴影区域的自动提取方法研究. Geomatics & Spatial Information Technology 33(5), 3–7 (2010)
7. Dong, B.-G., Qin, Z.-Y., Zhou, L.-Y., Li, H.: Study on Some Key Techniques of Thick Cloud Removalin Panchromatic Remote Sensing Image,全色遥感影像上厚云去除的若干关键技术研究. Journal of Information Engineering University 12(4), 494–499 (2011)