COMPARISON OF MULTIPLE TECHNIQUES FOR CLOUD COVER ESTIMATION USING THAICHOTE SATELLITE IMAGE

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KEY WORDS: THAICHOTE, Cloud cover estimation, Histogram segmentation, Comparison techniques, Optical satellite image

ABSTRACT: One of the major problems of the optical satellite image is cloud cover mapping. To satisfy the request of the customer, the information on percentage of the cloud cover in THAICHOTE images is necessary. Knowing the cloud cover content, it is possible to predict the portion of the error of the analysis. The cloud cover measurement should be automatically processed to generate and attach cloud information within the achieving system. This paper proposes the automatic cloud coverage estimation for THAICHOTE satellite images and the verification processes. The process of the proposed system is developed from the existing algorithm, which consists of the image classification based on histogram segmentation, the mathematical morphology fill region and holes have been applied in this process. To verify the accuracy of the proposed system, the THAICHOTE images have been compared between manual and the automatic detection. The results indicate that the indication of the percentage of the cloud in the image is useful for user to select the image for their applications. Moreover, the verification of the proposed system has been compared to the object-based classification technique.
For the future work, the final algorithm has to be integrated to the archiving system. The new system should be able to measure the percentage of the cloud in the satellite images automatically and attach this cloud percentage within the information data for each image in the THAICHOTE archiving system.

1. INTRODUCTION

The satellite image is the main important tool to extract the Earth's surface information. It has been widely used in many different applications with large area coverage region (Soontranon et al, 2015), for instance, urban sprawl mapping, land use land cover change detection, crop growth monitoring, etc. The cloud cover is spectacular problem for land surface analysis. Only small percentage of cloud cover in the image could result in land use classification results. For the archiving system, the cloud image archive with the large area of the memory storage. In the users side, the cloud cover normally represent as unwanted information (Huang et al, 2010). Therefore, the percentage of cloud cover of each image in archiving system is useful to enable users to select image that answer their request and reduce the image selection process time consuming.
In this study, the cloud automatic detection based on histogram segmentation has been presented. The output of the percentage of the cloud in the THAICHOTE satellite image was compared with the manual detection and the commercial software. The automatic detection system consists of several module include morphological mathematic technique. The rest of the paper was performed as follow: Section 2 presents the specification of the THAICHOTE satellite and its images. Section 3 describes cloud cover estimation by automatic detection algorithm system. Section 4, the experiment and results are examined. Section 5 performs system accuracy and comparison techniques. The final section gives conclusion and identifies future work.

2. THAICHOTE IMAGE

2.1 THAICHOTE specification

There were many years of using remote-sensing data from different type of satellite systems. Thailand decided to acquire their own satellite for Earth observation, which was operated by GISTDA (Geo-Informatics and Space Technology Development Agency). THAICHOTE have been launched in the orbit since 1st October 2008. It has gained 8 years to serve Thailand and global for optical satellite image (Vongsantivanich, et.al, 2015). The panchromatic and multispectral images are the main payloads of THAICHOTE (Kaewmanee, 2008). The panchromatic resolution is two meters, while multispectral is 15 meters. There are four bands consisting of blue, green, red and near infrared bands, respectively. It is circular sun-synchronous low earth orbit at the altitude of 822 km. The orbit period 101 minutes and inclination are 98.7 degree (Kaewmanee, 2008).

2.2 THAICHOTE image

The example of THAICHOTE image has been used for this study in order to demonstrate the result of the proposed algorithm. The image is multispectral, which has been taken in Nakhonratchasima Thailand. Figure 1 shows the THAICHOTE image of Nakhonratchasima area.

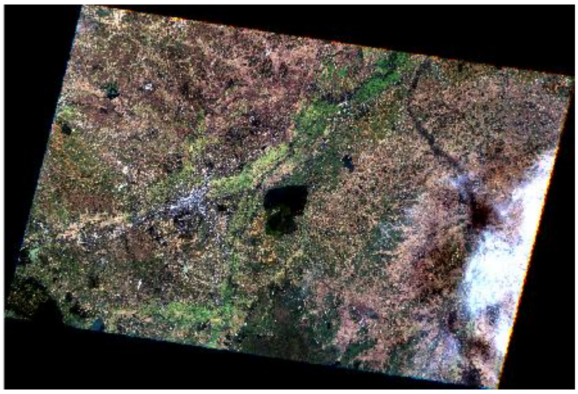


Figure 1 THAICHOTE multispectral image of Nakhonratchasima Thailand.

3. CLOUD COVERAGE ESTIMATION BY AUTOMATIC DETECTION ALGORITHM SYSTEM

This section presents the cloud cover automatic detection algorithm based on histogram segmentation, which is used to identify clouds in the input satellite image. The classification concept is using the histogram thresholds of the image. The different intensities are matching to the different objects in the image by considering each peak of the histogram and then mapping to the objects (Kurugollu et al, 2001). This paper has determined groups of cloud separate from the rest of the image. There are three main experiment to perform, i.e., the cloud automatic detection algorithm, the manual detection, and the cloud estimation using commercial program. Figure 2 demonstrates the flow chart of the cloud automatic detection algorithm.

The proposed system to detect cloud cover in the THAICHOTE automatically consists of four main modules.

i) THAICHOTE image was converted to gray scale image. The process was based on brightness of each pixel to a gray level usually 256 levels (Rafael 2008, Saravanan, 2010). The suitable method to perform the gray scale image of each image is depended on the nature of the input color image and the expected image result.

ii) The histogram segmentation, the threshold was calculated by using the sampling information from cloud pixels. The sampling pixel were analyzed for statistical feature such as minimum, maximum and average values for preliminary design. Threshold was applied to the image for detect the cloud in the image.

iii) Deleted small area and remove all connected component that have fewer than setting pixels. This operation is known as an area opening.

iv) Mathematical morphology technique. The morphological dilation process helps to connect areas, which were separated by smaller spaces than that of the structuring element used. Moreover, the technique to fill image regions and holes were enabled boundary line to be identified the cloud mask image (Zhang et al, 2009).

Thus, the cloud mask image was applied back to the original image to boundary only cloud area. Then, the percentage of the cloud were calculated.

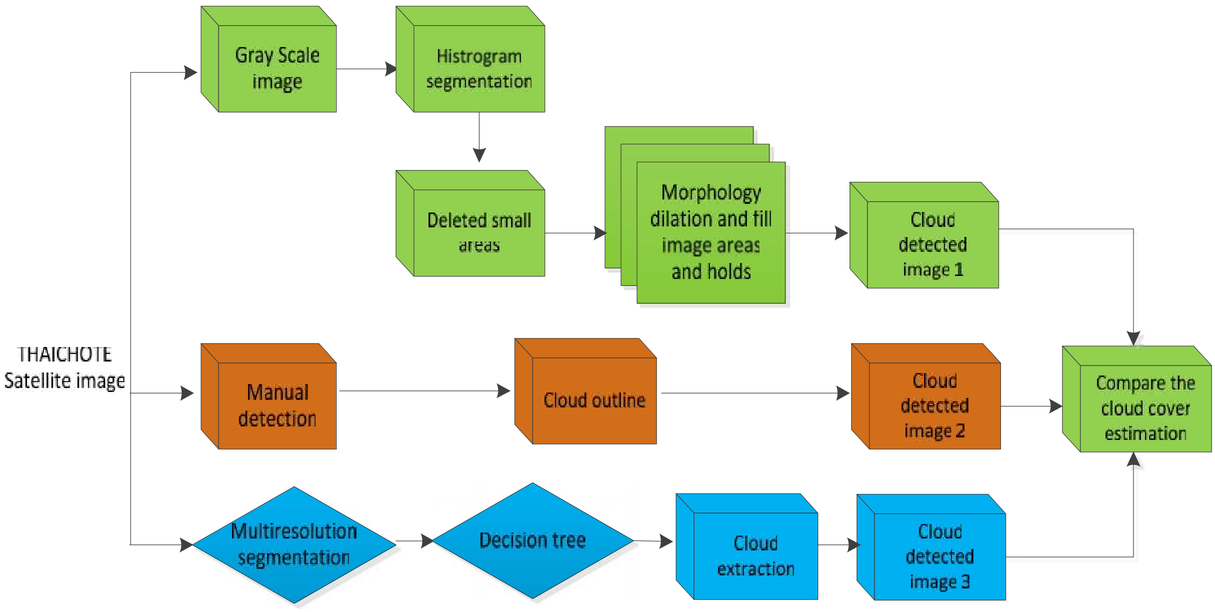


Figure 2 Automatic detection and comparison processes

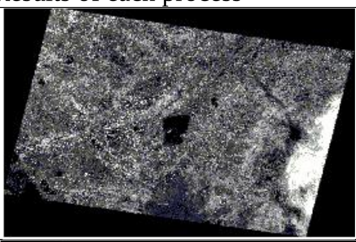
Second method to detect the cloud cover was manual detection by using the outline drawing on the input image. The detection was performed by operator with visual image classification. Then, the results from both two methods were compared the percentage of cloud cover.

The third method to detect the cloud cover was commercial software, i.e., eCognition. The process consists of multiresolution segmentation, decision tree, and cloud extraction (Zue et., al, 2012). Then, the results from this method was compared the percentage of cloud cover with those two methods.

4. EXPERIMENTAL AND RESULTS

The cloud coverage estimation using automatic detection has been examined. The detection was based on histogram segmentation technique, deleted small areas and morphological mathematic techniques. The image results of each process were shown in Table 1. Table 2 shows the results of the experiment for THAICHOTE satellite image, the pixel number of cloud and percentage of different between automatic and manual detection.

Table 1 The output results of each process in the cloud automatic detection system

Processes	Results of each process	Processes	Results of each process
1. Gray scale image		3. Morphology dilation	
2.Histogram segmentation		4. Cloud image	

5. SYSTEM ACCURACY AND COMPARISON

This system has been examined the correctness by comparing the number of pixels between the proposed system automatic detection and the manual cloud detection method. Both cloud detected area from automatic and manual were compared by counting the number of different pixels. Then using the number finds the percentage of the same pixels of clouds area of both images. The manual detection was performed by manual draw the outline around the area of cloud as shown in Figure 3. The figure 4 shows both image of cloud (a) automatic detection and (b) manual detection. The figure 5 illustrates the pixels that were different between both cloud detected images. The result of the experiment shown in Table 2. The example THAICHOTE image have been tested for three time to precise more experiment accuracy.

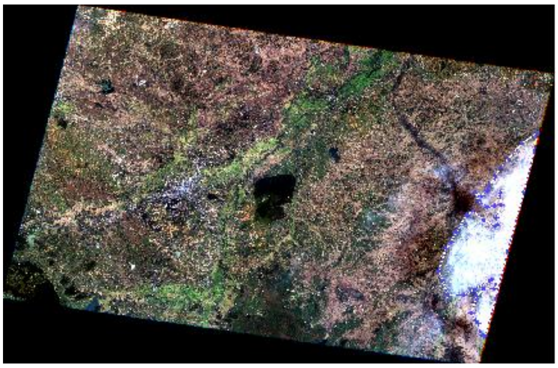
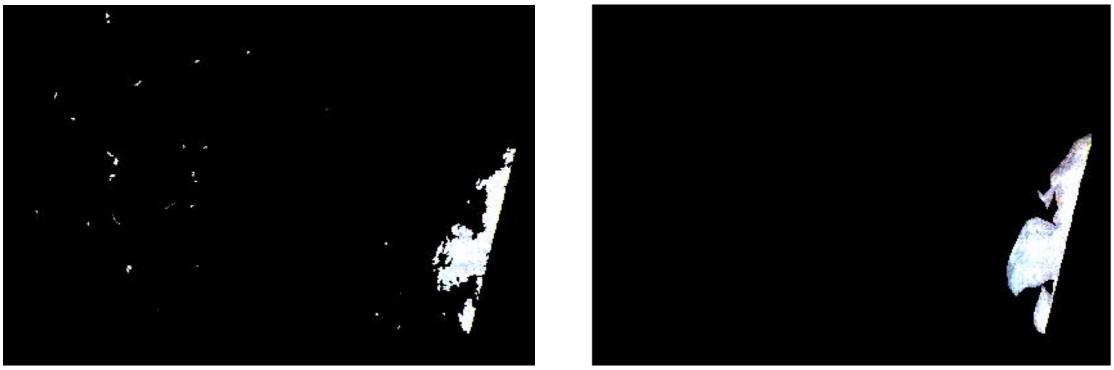


Figure 3 The manual detection



(a) (b)

Figure 4 (a) Cloud automatic detected (b) Cloud manual detected

Figure 5 The image show the pixels that were different between two detected techniques

Table 2 demonstrates the test results such as number of cloud pixels, number of the same pixel between the cloud image from automatic and manual detected and the different pixel number between these two output images. The experiment show that the percentage of the cloud in this image was around 3.10 percent of the image detected from the automatic proposed system. For the test number 1, 2 and 3, the number of pixel different between cloud automatic detection and manual detection was 1.89 %, 2.38 % and 2.19 % respectively.

Test results		Test no. 1	Test no. 2	Test no. 3
Automatic detection	Count pixel real image	51,600,454		
	Count pixel cloud	1,602,021		
	Percentage of cloud	3.10 %		
Comparison (Auto vs Manual)	Number of the same pixels	50,626,428	50,370,045	50,467,590
	Number of different pixels	974,026	1,230,409	1,132,864
	Percentage of different between auto & manual	1.89 %	2.38 %	2.19 %
		Average 2.15 %		
Commercial program	Percentage of different between auto & manual	2.73 %		

Table 2 The experiment results of the proposed cloud automatic detection and manual detection

Moreover, the system accuracy has been validated by using the comparison result with the cloud detection using eCognition commercial software. As the result below shows the images of (a) the cloud detected image (b) the cloud outline detection in the original image using eCognition. The result shown that there is cloud cover in this image around 2.73%.

(a) (b)

Figure 6 The cloud detection from eCognition commercial software
(a) Cloud detected (b) Cloud outline in the original image

The comparison of the output from the automatic detection, manual, and object-based technique. There are some miss classified result occurred. For instance, the area of urban consists of many building in white color. The automatic detect had detected these building to be cloud. Due to the reflectance value of buildings is similar with reflectance value of cloud objects. The system needs more ancillary data and classification techniques to detect more accuracy of each objects.

6. CONCLUSION AND FUTURE WORK

This paper study the cloud cover assessment for THAICHOTE satellite image by comparing the result from using the automatic detection based on histogram segmentation techniques, the manual detection and object-based technique. The proposed system is being able to detect the cloud in the satellite image and represent by the percentage of the number of cloud in the image. Moreover, the system have been verify the accuracy by using two different types. Firstly, the automatic system was compared with the manual cloud detection. Secondly, the system was compared with the result from eCognition software. The result shown that the cloud cover from these three methods provided the number of cloud cover for the example image: 3.10%, 2.15% and 2.73% from automatic, manual and eCognition detection respectively.

The information about cloud cover in THAICHOTE satellite is useful for achieving system. The operators would be able to search the image that has the number of cloud in the image. It is not over the rage of requested from the user. Therefore, future work is how to identify many different types of clouds in the THAICHOT image and add more classification technique for more detection accuracy.

7. REFERENCES

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