ASSESSMENT OF CLOUD AREA USING FIELD SERVER AND IMAGE PROCESSING

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ABSTRACT: Knowledge regarding the cloudiness is very important in Metrological Science. Cloud area is one significant factor to indicate the weather condition. Weather is an external factor to influence crop growth. In this work, the field server with common camera which is used to observe both a crop field and the weather at the same time is proposed. The main purpose of this research is to automatically assess cloud area in the sky from the images that are provided by field server. The image is a composition of the field of the crop such as rice, sugarcane and cassava etc. for monitoring crop growth and the sky area for observing the weather condition. In this research, the sky area is only concentrated for detecting cloud region. Firstly, Otsu's threshold algorithm is used to automatically separate the sky area from the others. Color index is conducted as the feature to tolerate the variation of light intensity in each day. In order to avoid the effect of diverse depths in the image, correction of the color index using virtual depth effect is required for correctly separating two classes in classification step. Supervised Bayesian Classification is performed to extract cloud area from the sky. Lastly, the cloud and sky areas are compared to calculate percentage of cloud amount in the sky. The experiments were conducted on rice field in Roi Et province, Thailand in November 2013. The result showed that our proposed method estimates cloud area effectively.

1. INTRODUCTION

In Meteorology, cloudiness is an important atmospheric factor. In order to understand or observe weather process known as Metrological phenomena (Ahrens, 2009), cloud area in the sky is one parameter to indicate the weather condition. Weather condition is a major factor for crop growth. If we know the weather condition, we can use the information for monitoring crop growing state or yield prediction.

Equipment and systems have been developed to monitor and estimate cloudiness effectively such as SONA (automatic system of cloud observation) (Gonzales et.al., 2012) and cloud detection system using radiation and image (Martínez-Chico et.at., 2011). Various techniques with image processing were introduced to estimate cloud coverage (Davis et.al. 1992; Calbo and Sabburg, 2008).

Moreover, Satellite observation has been used to measure cloud coverage on large area efficiently. Zhu (Zhu and Woodcock, 2012) presented cloud observation using LANDSAT data and Ameur (Ameur et.al., 2004) introduced detecting cloud area using Meteosat satellite imagery.

In general research on detection of cloud coverage uses common camera which takes photos only focusing on the sky area. Meanwhile, in this research, we propose the remotely instealled camera system that can observe both a crop field for monitoring crop growth state (Sritarapipat et.al.; 2014, Soontranon et.al., 2014) and the weather condition at the same time without installing additional camera.

In this paper, a method for estimating cloud area by using the field sever and image processing technique is proposed. The images providing the sky area and still observing the crop are acquired by field server and then image processing method is used to assess cloud area in the sky under negative conditions of light intensity and depth of object in the image.

2. MATERIAL AND METHODOLOGY

A field server (Fukatsu and Hirafuji, 2005) was installed at the field crop to monitor the crop and the weather condition. The field server with various sensors (figure 1 (a)) provides the information such as temperature, pressure, humidity also image etc. In this research, a camera sensor that daily provides RGB images was installed. Commonly, if we need to measure cloudiness, the camera will be focused on vertical-axis or looking directly at the sky. Since we need to observe both crop field for monitoring crop growth and the sky for observing the weather condition, camera will be focused on horizontal-axis. As a result, the acquired image is a composition of crop field and the sky areas (figure 1 (b)).

(a) (b)

Figure 1. Field Server (a) and acquired image (b)

Image processing technique (Gonzales, 2008) is employed to estimate cloud area in the sky. Firstly, Otsu threshold algorithm is needed to automatically separate the sky area from the others. The sky area is only concentrated for detecting cloud region. Color index is used as the feature to tolerate the variation of light intensity. Correcting color index affected by diverse depth is needed. Supervised Bayesian Classification is performed to extract cloud area from the sky. Lastly, the cloud and sky areas are compared to calculate percentage of cloud amount in the sky.

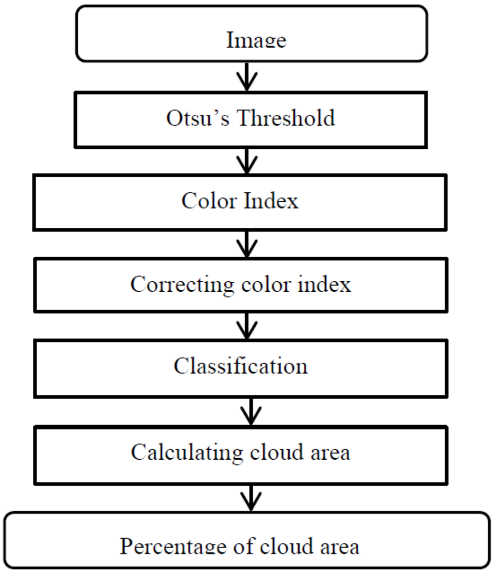


Figure 2. Process of cloud area estimation

2.1 Otsu's threshold

The image (figure 1 (b)) acquired by field server is composition of (1) the crop field area; crop, tree, other objects such as a pole (2) the sky area including cloud area. For only computing the sky, Otsu threshold (Sezgin and Sankur, 2004) is performed to separate the sky area from the crop field area. Otsu's threshold is a non-parametric unsupervised method to select threshold that clusters into two classes. In this case, considering blue band image, we found that blue band value of cloud area is high (white color) and blue band of crop field area is low (black or dark). Hence, Otsu's threshold is suitable method to automatically distinguish these two classes among variation of light intensity in each day. The resultant image (figure 3 (b)) is defined for sky area as 1 or white color and for non-sky area (the crop field area) as 0 or black color.

(a) (b)

Figure 3. Blue band image (a) and masked sky image (b)

2.2 Color index

Unfortunately, light intensity while taking the image always changes in each day, it will be hard to automatically classify between cloud and cloudless areas. Color index (Meyer and Neto, 2008) is used as the feature to robust the variation of light intensity. For color index, the normalized red minus blue (NRMB) was considered that cloud and non-cloud area in the sky are clearly different (figure 4(a)) and its equation can be expressed as

$$Normalized\ red\ minus\ blue = \frac{(Red - Blue)}{(Red + Blue)} \quad (1)$$

In order to measure cloud area in the sky, the sky area that is obtained from the previous step is only concentrated for detecting cloud region (figure 4 (b)).

(a) (b)

Figure 4. Normalized red minus blue image (a) and sky-masked normalized red minus blue image (b)

2.3 Correcting the color index

Since the camera was focused on the horizontal-axis, the objects in the image have different depths that make up different color indexes. The sky area in figure 4 (b) illustrates that the values of NRMB will decrease when the number of row increases. Without correcting the effect, it is not possible to successfully classify and find the threshold which correctly separates two classes among gradually changed values by increasing rows in the image. In order to correct the color index affected by depth variation, the clear sky image was chosen to meet correction model. A linear function is defined for correcting the color index and expressed as

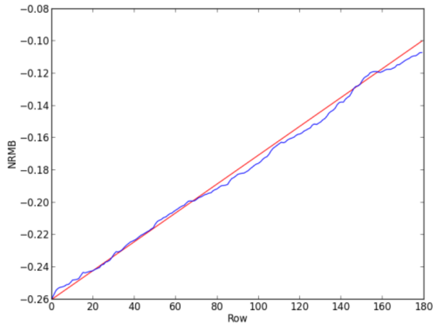
$$\mathrm{NRMB}^{new}(\mathrm{i}) = \mathrm{NRMB}(\mathrm{i}) - \mathrm{Gain(i)} \quad (2)$$

$$\mathrm{Gain}(\mathrm{i}) = \mathrm{i} \times \mathrm{STEP} \quad (3)$$

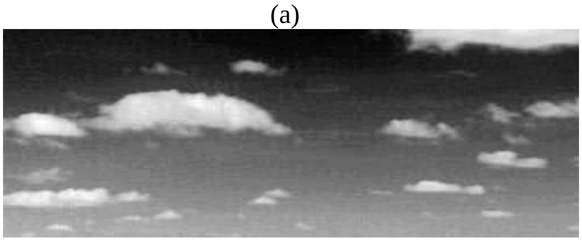
$$\mathrm{STEP} = \frac{\text{(estimated value at last row − estimated value at first row)}}{\text{number of rows}} \quad (4)$$

where i is index of row and STEP can be observed from the varying value from first row to last row in clear sky image (figure 5 (a) and (b)). The correcting result (figure 5 (d)) illustrates that the values of NRMB do not change as increasing row changes (figure 5 (c)).

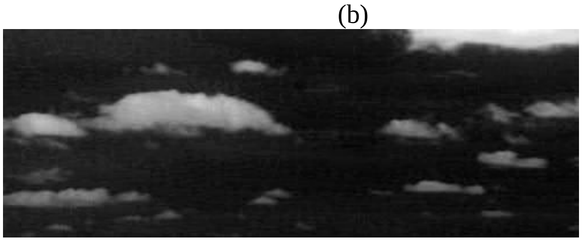
(a)



(b)



(c)



(d)

Figure 5. Clear sky ROI of Image (a), Relationship between NRMB and row (NRMB column's mean line: blue color, estimated line: red color) (b), NRMB ROI of Image (c) and Correcting NRMB ROI of Image (d)

2.4 Classification

Bayes Supervised classification (Devroye et.al., 1996) is applied to separate between cloud and cloudless areas. A Bayes classifier is a simple probabilistic classifier based on applying Bayes' theory. Data from two classes in correcting NRMB image was selected to train the classifier. In Bayes classification process, the correcting NRMB image is computed and turned into resultant binary images; "1" for cloud area and "0" for non-cloud area (figure 6 (a)). For combining the result of cloud area with sky mask, the three classes were represented as RGB image; black color for non-sky area, blue color for cloudless area and white color for cloud area (figure 6 (b)).

(a)

(b)

Figure 6. Resultant ROI of Image (a) Resultant RGB Image with sky mask (b)

2.5 Calculating cloud area

Percentage of cloud area in the sky can be calculated from the equation.

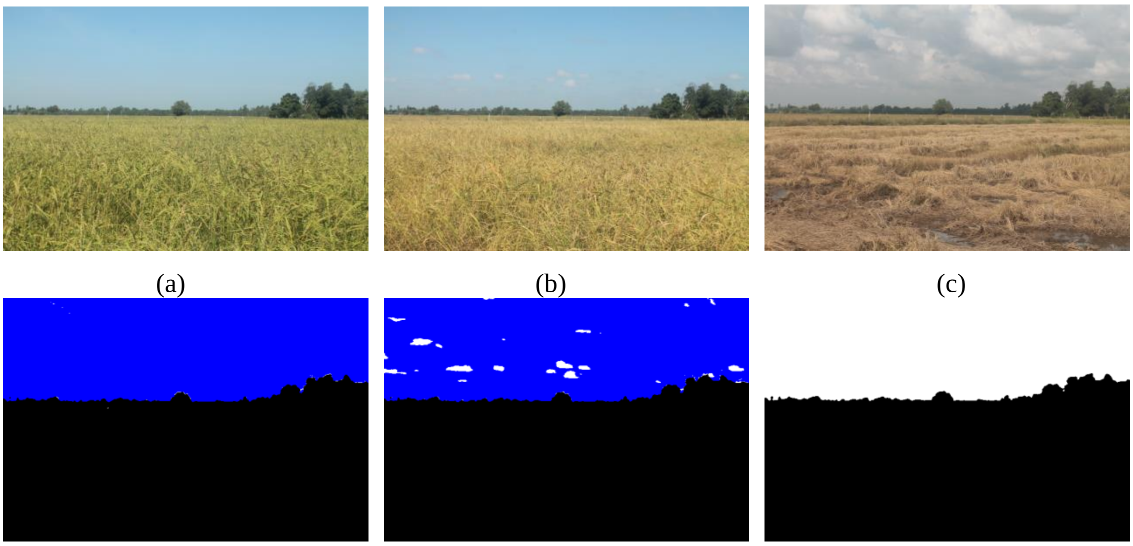
$$Cloud\ area(\%) = \frac{Pixels\ of\ cloud\ area\ in\ the\ sky}{Pixels\ of\ cloud\ area} \times 100 \quad (5)$$

For this example, percentage of cloud area in the sky is about 15.40%.

3. EXPERIMENT AND RESULT

The experiment is conducted on the rice crop field in Roi Et province in northeast region of Thailand, one of the main agricultural areas. In this research, we observed the weather condition of the site in November 2013. We selected six significant images with three cases; no cloud, some cloud and full cloud for testing with our proposed method.

For visual evaluation, the comparison between resultant and RGB images (figure 7) were selected to demonstrate three cases (figure 7); no cloud cover, some cloud cover and full cloud cover. These percentages of cloud area in the sky computed by this method are about 0.09%, 2.50%, 99.99%, respectively.



(a) (b) (c)

(d) (e) (f)

Figure 7. Comparison between RGB and resultant images; No cloud cover (a and d), some cloud cover (b and e) and full cloud cover (c and f)

In both visual and quantitative evaluations, the proposed method had efficiency in measuring the cloud area in the sky with variation of light intensity and changing the color index by depth effect.

For quantitative evaluation, six selected images were manually measured. The comparison between resultant classifications by manual method and our proposed algorithm is shown in table 1.

Table 1. Comparison between referral and estimated three classes (Non-sky, Cloud, Cloudless areas) and clod area in the sky (gray highlight)

Image	Non-sky area (%)		Cloud area (%)		Cloudless area (%)		Cloud area in the sky (%)	
	Reference	Estimate	Reference	Estimate	Reference	Estimate	Reference	Estimate
No cloud I	60.37	60.14	0.00	0.02	39.54	39.84	0.00	0.04
No cloud II	60.33	60.11	0.00	0.06	39.43	39.83	0.00	0.15
Some cloud I	60.19	60.16	0.99	0.68	37.59	39.15	2.57	1.72
Some cloud II	60.26	60.27	4.32	5.37	34.33	34.37	11.17	13.50
Full cloud I	59.82	59.59	40.09	39.07	0.00	1.33	100.00	96.70
Full cloud II	60.49	60.60	39.46	39.39	0.00	0.00	100.00	99.99

4. CONCLUSION

This research paper introduced a method to assess cloud area in the sky using a field server and image processing technique. Field server provides images that focus on the crop field area and the sky area which is used to analyze for cloud region. Image processing method is performed to automatically estimate cloud amount in the image among problems with unneeded data (non-sky area) using Otsu' s threshold, variation of light intensity using color index and depth effect using virtual depth function. The experimental results showed that our proposed method estimates cloud area effectively among these problems.

5. ACKNOWLEDGEMENT

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