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An Automatic Solution for Quantified Measurement of Cloud Amount Using Whole-Sky Image

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Abstract: The cloud cover in the sky has been measuring by a human eyes up to now. Instead of the eye observation, computer aided automated cloud observation is applied to get the cloud amount or cloud cover. A rising issue is how to get the cloud area, since, the boundary of cloud generally is ambiguous. Some of studies related cloud generally used values of RGB or those ratios such as red green ratio and red blue ratio, etc. The present study developed algorithm of calculating the sky zone to get the cloud amount with the whole sky image data taken the image data taken the automatic cloud observation system operated by the Metrological Administration in Korea. The cloud cover announced by the Korean Meteorological Agency is the eye observation result, even though they have an intelligent cloud observation system. The reason is the impermissible error in the result data of the automatic observation system. The proposed solution is maintenance-free but the present solution has to be supplied sky extracting filter periodically to get the exact boundary between the sky zone and the obstacle objects in horizontal line. The obtained cloud amount or cover using the proposed solution is better reliable and precise than the current automatic cloud observation system at the Meteorological Agency.

Key words: Whole sky image, cloud observation, fisheye lens, sky edge detection, color filtering, administration, meteorological

INTRODUCTION

The cloud amount affects meteorological variables as well as weather forecast. It is an absolute variable for determining solar radiation and sunshine on ground. In addition, it is highly used in an industry using solar energy and air traffic as well as meteorological areas. However, cloud amount lacks an objective evaluation due to visual observation on the ground at present which has low spatiotemporal resolution. To overcome the limitations of bare-eye observation, satellite data are employed in calculating the cloud amount but they are not identical to those measured from ground and there is still a problem to get objective data. Therefore, WSI (Whole Sky Imager) and TSI (Total Sky Imager) are invited to improve the calculation of the cloud amount but few studies related to it have been conducted domestically (Kim *et al*., 2008; Kim, 2014). The present study developed algorithm of calculating the effective sky zone and cloud edges to get the cloud amount with the whole sky image data taken the image data taken the automatic cloud observation system operated by the Metrological Administration in Korea as shown in Fig. 1.

Fig. 1: Automatic cloud observation system

To evaluate the performance of the algorithm, comparison was made with the current used method, since, the result of the current method has not given reliable data compared naked eye observation. The whole sky image, obtained the automatic cloud observation system in Daikwanryoung weather observation station at in Korea has been analyzed. The result is shown that the proposed method has more reliable and accurate.

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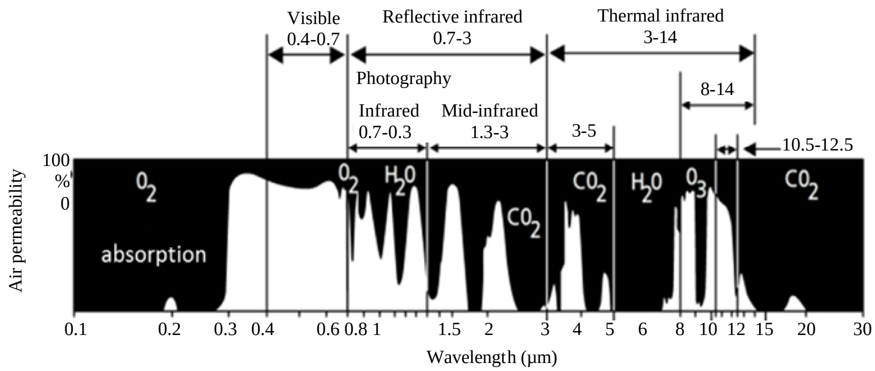


Fig. 2: Permeability related frequency and major absorption gas

Fig. 3: Obtained images of the automatic cloud observation system

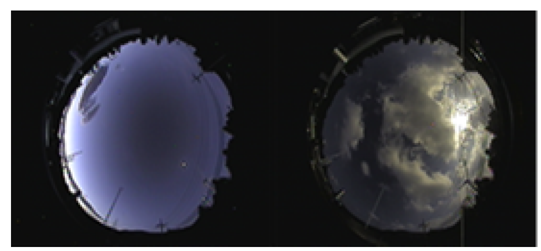


Fig. 4: Whole sky image obtained from the cloud observation system

However, more detailed analysis, seasonable a monthly analysis was required to get a universal commercialized method.

Literature review: The change of sky color at sunrise or sunset (red nearest the Sun, blue furthest away) is caused by Rayleigh scattering by atmospheric gas particles which are much smaller than the wavelengths of visible light. The grey/white color of the clouds is caused by Mie scattering such as water droplets, yellow dust or Asian dust, volcanic ash and sea salt particles which are of a comparable size to the wavelengths of visible light (Fig. 2).

The cloud amounts, one of the basic important parameter in atmospheric observation have been observed by naked eyes of observers which are affected by the subjective view. In order to ensure reliable and objective observation an algorithm to retrieve cloud amount was constructed using true color images composed of Red, Green and Blue (RGB) (Kim *et al.*, 2008; Kim, 2014; Heinle *et al.*, 2010). The true color image is obtained by the automated cloud observation system as shown in Fig. 3. The principle of distinguishing cloud from sky lies in a spectrum analysis that the spectral characteristics of light scattering is different for air molecules and cloud.

MATERIALS AND METHODS

Proposed work

Circular fisheye whole sky image: The circular fisheye lenses take in a 180° hemisphere and projected this as a circle within the sensor area. These have a 180° vertical angle of view and the horizontal and diagonal angle of view are also, 180°. Most circular fisheye lenses cover a smaller image circle than rectilinear lenses, so, the corners of the frame will be completely dark as shown in the Fig. 4 (Shields *et al.*, 2013). The fisheye lens has been applied in automobiles and GIS, since, it has a wide angle (Han, 2016; Abbas and Mahdi, 2016).

Optical characteristics of sky and cloud: The principle of separation between clear sky zone and cloud zone is the spectral characteristics difference. Molecules in the air induce scattering. Therefore, the cloud amount could be obtained using true color images composed of red, green and blue since there are differences among RGB as shown in Fig. 5. The clear sky shows different intensities depended on RGB colors, however, the cloudy zone shows that the intensity of each color fluctuates with time but their intensities are not much different.

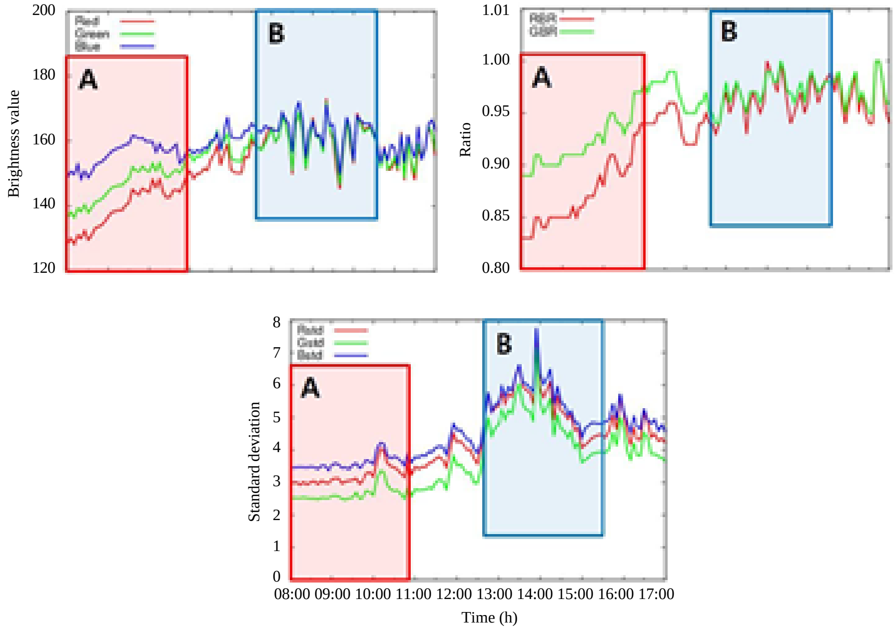


Fig. 5: Whole sky image analysis (Region A: clear sky, Region B: cloud) ave. of brightness of RGB (top), comparison of ave. of RBR and RGR (middle), ave. of standard deviation of brightness of RGB (Abbas and Mahdi, 2016). Effective sky zone extraction

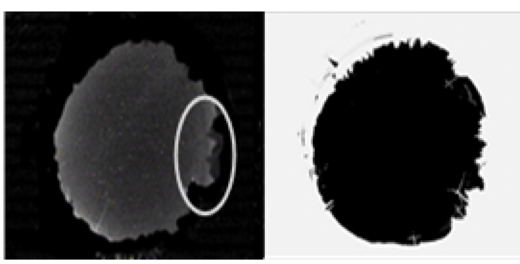


Fig. 6: The effective sky zone of the current method (left) and the proposed method (right)

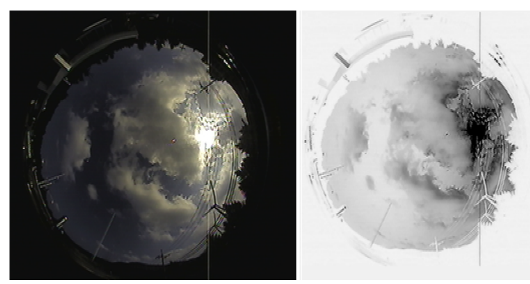


Fig. 7: The comparison between the original image and the processed negative intensity image

RESULTS AND DISCUSSION

The current surrounding of the observation system has problem since the border of image circle includes the obstacle such as building, trees, electric power line and some utility poles. The current solution is that the image is periodically obtained and revised manually to make a filter to extract the sky region but the proposed method calculates automatically using constraint conditions which are included in the whole sky image and system parameters. Figure 6 shows the difference that the left image is processed by the manual works. The street light and its pole are disappeared and the top of trees at the middle of right are new obstacles. The right image is processed automatically using the proposed method and the inside edge is exactly the observed sky zone. By scanning from the center to the edge, the sky zone is able to get the number of pixels of the sky zone (Shields *et al*., 2007, 2009).

The previous study shows the separation of clear sys and cloud is more precise and convenient if the HIS (Hue, Intensity and Saturation) system is applied as shown in Fig. 7. It may be applied to be observed for the cloud type and the cloud height which are also, required parameters for the cloud observation. The right image in the figure shows that the brightness in the image is free and the Sun's influence is less than the original image.

This groundwork study is part of developing an intelligent cloud observation system for the Meteorological Agency in Korea. The effective

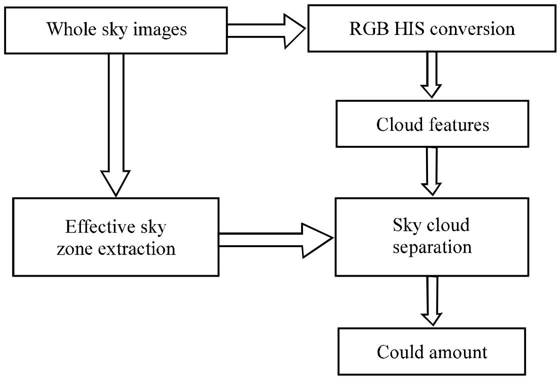


Fig. 8: The block diagram of the proposed solution

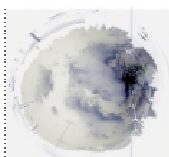
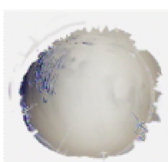
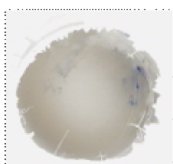
Whole sky (Negative intensity)	Cloud cover	Whole sky (Negative intensity)	Cloud cover
	10.6%		65.0%
	16.6%		4.6%

Fig. 9: The result for cloud cover of the proposed solution

observation sky area is defined and the obtained sky area does not require extra manual work to make filter to get the sky area. It is obtained automatically from the exactly same original image. The proposed cloud amount measuring solution is shown in Fig. 8 and 9 which is the block diagram of the proposed solution for cloud amount observation. It will be extended to measure the cloud type and height.

At the present time, the result of a pilot solution is shown in below and the solution requires some improvement. It will be tested after modification and packaging. However, the obtained cloud amount or cover using the proposed solution is better reliable and precise than the current automatic cloud observation system at the Meteorological Agency.

CONCLUSION

The proposed solution will be applied to observe the cloud amount automatically to substitute the eye observation for the Korean Meteorological Agency. For those application, a kind of complete generality and preciseness are secured. The solution is able to calculate the ratio of clear sky and cloud cover and the output of the solution is more reliable than the result of the current using solution.

RECOMMENDATIONS

To evaluate the proposed solution, the result of the solution will be compared with the recording data of Korean Meteorological Agency. However, one of advantage of the new solution is maintenance free for surrounding obstacles in horizontal line such as trees, electric poles and wind power generators due to the high mount ratio, about 70%. The other advantage is the automatic self-correction of sun rising and sun set time since the position of sun is major inducing error factor to distinguish between the clear sky and cloud.

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