Image Analysis by Drone System for Environmental Inspection

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Keywords: Drone System, PM2.5

ABSTRACT

This report explores the application of the aerial image system that integrated with the micro-recorder or micro-projector for environmental inspection. Corresponding display technology, combined with drones and artificial intelligence, judgment criteria, can improve the application and complete the contribution of image display technology for cross-discipline application.

1. INTRODUCTION

Pollution in the atmosphere has become a really significant issue. In order to resolve this problem, researchers have developed various methods for studying and assessing air pollution. The most usual method is light scattering techniques with UAV [1]. The sensor receives scatter light of tiny particles, in which generated by the light source, and measures the corresponding pollution after hitting the sensor. However, such a measurement method has a major problem in that it is difficult to miniaturize the system as the payload, and data of a large area cannot be obtained within a short time. Method of using optical images for pollution measurement has been proposed [2-3].

Figure 1 shows the principle of the pollution image based on the contrast ratio of the B/W or RGB primary colors of the actual measurement image [4]. The simulation method uses different transparency to represent the level of air pollution (PM2.5). In this report, we demonstrate the contrast ratio strategies to calculate the PM2.5. The present techniques can be treated as a simplified MTF based method, which is to measure the change of MTF corresponding to a remote image target and then to complete the correlation coefficients between air pollution index and the images. The vantage of this type of method is that one can get rid of the targeting setting issue.

2. MATERIAL AND METHODS

2.1 measurement system with target contrast

Previous publication is for the grounded base system, while present approach is the imaging system on the drone as payload. The test charts represent actual objects. The method shown in the first column (***real images***) of figure 1 is a physical simulation and the second column (***the virtual images***) is a method using a virtual projection technique. Here specify the contrast ratio:

$$C \equiv \frac{E}{I} \qquad (1)$$

Where E is the measured luminance of a given target images (real or virtual), I is the measured luminance for the environmental background. Recall the standard strategies, for real images, the environment background I is the function of the pollution (f (25)··· f (75)). This, a possible scenario is that the target images is blocked by the pollution, which leads to an undefined contrast ratio, fs the pollution is large (i.e. 0/0=?). As for the proposed method, there is no such problem. All the numerical calculation is stable if the image qualities of the projected virtual images on the UAV are satisfied. Figure 2 shows the proposed configurations.

2.2 measurements by background contrast

Another method is easier, but supposed with lower accuracy. Figure 3 shows the key equipment for this approach, and we introduce the SJ5000X ELITE sports camera (table 1) that setup on the drone. In the meantime, PM-1063SD air quality monitor/recorder is prepared for the later ground calibrating. Through the calibrating, one can establish the Pearson Correlation Coefficient ρ (between the defined contrast ratio C and the PM2.5). After that, the images taken by the drone system will be analysis by taking the Color-RGB values of the marked position. ImageJ software is applied to complete the image analysis.

Figure 4 shows the marking position for the RGB color analysis. Notice that due to the geographic conditions, it is needed to introduce the AI edge detection routines, such that the computation of the regional images features can be more precise. Table 2 gives the corresponding RGB values for selected positions marked in figure 4. Now the brightness are obtained through equation (2), and the equivalence illuminance is calculated by equation (3), with a conversion factor α. Finally the contrast ratio for this procedure is defined as equation (4). At the present moment α will be eliminate in equation (4) under the assumption that in the selected region α is a constant. Still, for more complicated situation the variations of the conversion factor should be set into consideration.

$$B = 0.299R + 0.587G + 0.114B \quad (2)$$

$$\mathrm{I} = \alpha \cdot B \quad (3)$$

$$C = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} \times 100\% \quad (4)$$

3. DISCUSSION

We complete and integrated the payload. The first one is the lightweight PM2.5 sensing module, which is based on the Sharp PM2.5 DN7C3CA007. The module is inexpensive and lightweight. The second payload contains the optics system. The specification of this Drone lens is FOV 84° with 8.8mm/24 mm (equivalent to 35 mm format), while the f number varies between f/2.8 - f/11 with autofocus (focus distance 1 m - infinity). Note that a 1 inch CMOS effective pixel 20 million, and 4K imagers with 24/25/30/48/50/60p under 100Mbps.

Figure 5 gives the comparison of imaging and PM2.5 measured by the drone, and figure 6 give the relationship between the measured PM2.5 and the contrast ratio that calculated by the equation set. In general, higher PM2.5 reduce the contrast ratio C, and the Pearson coefficient is -0.43 in this case. Note that this result is based on the background contrast method. Results for the target contrast method will be demonstrated on site.

4. CONCLUSION

In practice, it cannot be completely achieved and the analysis cannot be performed for different wavelengths. To overcome this, this report proposed a novel method that using the virtual display to complete the calculated to complete air pollution for large area. An algorithm is proposed that can implement and integrated with the existing drone system, such that increase the adding values of the present architectures for environmental inspection through the display image technologies.

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Acknowledgements

Financial support of this research from the Ministry of Science and Technology of Taiwan under grant nos. MOST 105-2221-E-164-004, MOST 106-2221-E-164-006 and MOST 107-2221-E-164-002 are most appreciate.

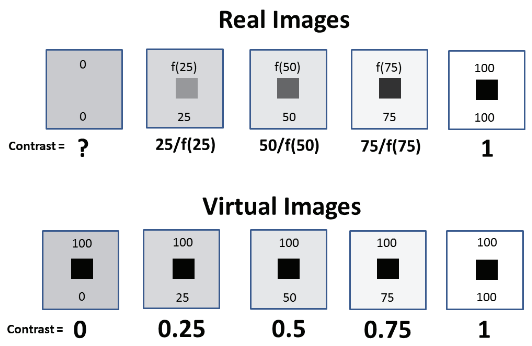

Fig. 1 comparison of contrast ratio methods for PM2.5 measurements using projection images [4]

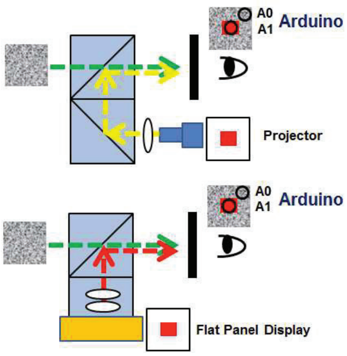

Fig. 2 configurations for the projection system

Fig. 3 measurement system by background contrast

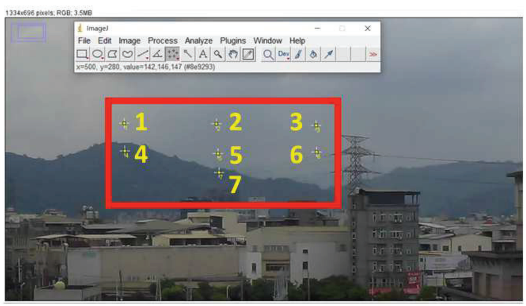

Fig. 4 selected marking position for RGB values

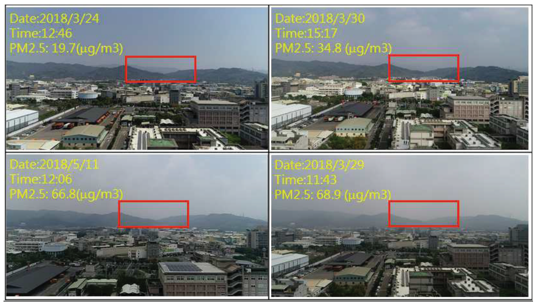

Fig. 5 Comparison of imaging and PM2.5

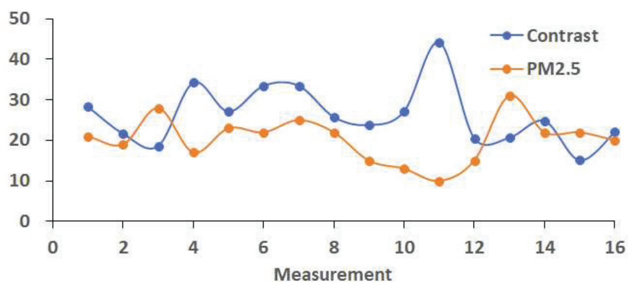

Fig. 6 relation between PM2.5 and contrast ratio by

Table 1: Specification for drone imaging system

Photo Resolutions	12 MP (4032*3024) 10/8/5/3/2MP
Maximum Video Resolutions	4K @ 24fps (interpolated)
Sensor	Sony IMX078
Chipset	Novatek 96660
Sensor Resolution	12.4 MegaPixels
WIDE ANGLE	70-170°
Max Bitrate	Up to 30mbps

Table 2: RGB values using ImageJ software

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data / point	R	G	B	Brightness
1	138	142	145	141
2	120	130	139	128
3	125	134	139	132
4	066	082	097	079
5	112	125	131	122
6	117	128	134	125
7	070	088	100	084