Using Digital Image Processing in analyzing Air Pollutants’ Effects for two Smoke Types Upon a Colored Tested Image

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Abstract. Local environmental problems such as noises, red tides, air pollution and water clarity that obstructed the comfortable human lives take an attention through the last few decades. Air pollution as an example can cause a variety of health problems, and may cause haze, smog, reduces visibility, dirties, damages buildings, other landmarks, and harms trees, lakes and animals. So, in order to study smoke effect, a comparison study for two smoke types had been taken into considerations to study air pollutants upon a colored scence inside a wooden system designed for this purpose. In such system two kind of smoke sources had been utilized, a burning incense is used as a white smoke emission and the second one is by burning a piece of rubber and nylon with crude oil as a source for black smoke emission. Results show a similar behavior of the wavelength spectrum of all ink colors for both smoke types. The particulate oil in the black smoke affects strongly upon an ink absorption/reflection spectrum through shifting the spectrum toward the lowest values of gray level intensities (i.e. darker pixels) and this is due to the higher scattering efficiency which is dominant in this case.

Keywords: air pollution, scattering, mean estimator, wavelength spectrum, black smoke.

1. Introduction

The rapid industrialization in addition to the use of automobiles for transport to cope with the growing demand of the increasing human population had been considered as the main sources of air pollution. Air pollution has various harmful effects upon human health depend on the nature and concentration of such pollutants in the surrounded air causing bronchitis, silicosis, lung cancer etc.[1,2].
In 1995, Cheng Y S et al founded that the produced aerosols from burning an incense are similar to others formed by environmental indoor tobacco smoke and the authors estimated the rate of aerosol generation as a function of time in addition to the aerosol removal rate constant [3]. Kahforoshan D et al in [4] made a comparison study between a typical model for gas flare with experimental one obtained from the industrial city of Nigeria. They studied the affected parameters upon the dispersion pattern of pollutants. Al-Zuky A A D et al in [5] investigated the influence of scattering effects upon the used test image through analyzing the whole captured images from sunrise to sunset. They found that Rayleigh and Mie scattering are the dominant scattering types at certain times which works individually and affects together at another time periods. An evidence to the principle of wavelength attitude for an ink with different color pigments had been explained by Ahmed H M et al in [6] in previous research related to the topic of interest.

Basically, aerosol burden, and water vapor are the most essential variables which deplete solar radiation during its passage through earth atmosphere. Absorption, reflection, and scattering are the three mechanisms which are responsible for such depletion. The absorption is a selective process while reflection refers to the reflected coefficient in the spectrum visible range. The scattering well-known types are Rayleigh, Mie, and non-selective scattering. Rayleigh scattering is responsible for the blue color sky while the white appearance of the clouds is due Mie’s scattering effect. Both scattering and absorption are responsible for the radiant energy attenuation through the earth atmosphere [7].

In many applications, the digital imaging system can gather and hence display a huge information in a way that is obvious to others and for such task, one can used the computer for analysis and extract the quantitative information from the captured scene. Image analysis consists of techniques which compute statistics and measurements based on image pixels gray-level intensities and one of the most important spectral operation is the mean gray scale intensity [8].

2. Mean estimator
The mean grayscale values of an image can be given by the equation [7]:

$$\mu = \bar{g} = \frac{1}{n} \sum_{i=1}^{n} g_i$$  \hspace{1cm} (1)

Where n is the number of gray scale, $g_i$ is the value of grayscale image.

3. The Experimental setup:
The building system consists of a wooden rectangle box with dimensions 120x40x60 cm. The colored scene is illuminated by a white LED light located in the middle of the upper box’s side as shown in figure 1. The interior smoke had been obtained by two sources, one by burning an incense (i.e. Sheikh Al-Shuyakh incense) which produced a white smoke and the second source by burning a piece of rubber, nylon with crude oil to produce a black smoke inside the system. Images have been selected in a sequential frames through equally time periods from the captured videos for both types of smoke which fall into (15.6) minute for white smoke and (12.45) minute for black smoke.
4. Direct measurements for Interior illuminance:
Since the illuminance changes with time through the whole period of work, a direct measurements for the interior illuminance had been taken into considerations and measured by using light/lux meter. This process had been done here by using lux meter upon the colored scene for both white and black smoke for the whole two videos. The used lux meter is a silicon photo diode sensor with spectral response filter and fully cosine corrected. Figure 2 shows an illuminance variance with time for both smoke types respectively.

As expected, the interior illuminance shall be decreased as soon as the black smoke plumes constructed and this is achieved in figure 2b, noting that the peak appeared near the middle video interval for the white smoke as in figure 2a and at the upper and lower video intervals for the black one.
As a result found in [9], this effect can be explained by the multiple scattering occurrence for smoke when the later is high enough in its concentration inside the system.

5. Results for digital image analysis:
Figures 3&4 show some of the selected images starting from clean air case toward smoke-disappear one passing through the state of full-smoke for both white and dark smoke respectively. In order to analyse smoke behaviour through the whole two videos, equation 1 can be used to estimate mean values for a rectangle selected box from each image’s colors using matlab R2018a.
Figure 3. Some of selected images through different time periods for white smoke[6].
For both smoke types, the absorption spectrums of all ink pigments have the same attitude for all bands. This can be seen by noting figure 5. According to [6,10,11], the ink absorption spectrum contains a curved line with peaks and troughs. For both smoke types, each pigment transmits two thirds and absorbs one third of the visible spectrum to give rise to the specified color. Noting that for Cyan, Yellow, and Magenta, the complementary wavelength is the lowest curve as can be seen in Figures 5c,b&c respectively. An exception had been appeared in the case of White and Black ink colors which witnessed a similar attitude for Red, Green, and Blue bands with equally strengths as can be seen in Figures 5a&h respectively.
In the dark smoke case, a shift in the peak/trough appeared clearly for each band and this is due to oil pollutant emission which spread over the whole system and affects strongly upon the absorption spectrum for each colored ink. The latter result matches a reality found in [12] and such effect belongs to the highest scattering efficiency which shifts toward smaller values of particle size. The mean estimator as a result can be used as a good indicator for size parameter, refractive index and hence scattering efficiency.

![Graphs](a, b, c, d)  
*Figure 5. The variation of absorption spectrum for color pigments with time (left column) for white smoke [6], (right column) for black smoke.*
Figure 5. continued
6. Conclusion
This study aims to make a comparison between two states of smoke; white and dark smoke by analysing a colored scene inside an optical system prepared for this purpose. For both smoke types, results show a similar, and identical behaviour for all bands to each scene’s colors which verified the subtractive color mixing principle. Scattering efficiency appeared clearly in the case of using dark smoke through shifting the spectrum wavelength for all colors to the lowest values of gray level intensities. The mean estimator can be used in future as a good indicator to analyse a poorly contrasted image like polluted scenes.

7. Compliance with Ethical Standards
There is no conflicts of interest besides the research did not receive any specific funding but was performed as part of the employment of the authors.

8. Funding Statement
The research did not receive any specific funding but was performed as part of the employment of the authors.

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**Acknowledgments**

The authors would like to thank Mustansiriyah University (www.uomustansiriyah.edu.iq) Baghdad-Iraq for its support in the presented work.