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Effect of Contrast and Brightness on Digital Images under Outdoor Conditions

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

In the present scenario, the digital image processing has enveloped the whole world of advancing technology. The changes on-going in the world are directly or indirectly related to the processing of digital images. In this paper, we studied the impact of changing contrast and brightness on the digital images under outdoor conditions and checked out how the position of Sun effects contrast and intensity of the particular image and at what values of contrast and intensity, the pictures were more refined. A total of 52 images shot in North, South, East and West were taken for the experiment after regular intervals. Genetic algorithm was used by several authors to enhance the quality of images in terms of brightness and contrast. Here we investigated whether the brightness and contrast are direction and time orientated. The analysis shows that for the set of images taken, contrast is slightly affected by the whereas the effect of brightness is more pronounced with respect to time and direction.

Keywords: Digital image processing; contrast; intensity; image quality; image analysis.

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1. INTRODUCTION

A light source, sensors and the data card connecting the sensor device to the computer are the basic components of any digital image processing unit [1-2]. The quality of the digital images is directly or indirectly related to the illumination source or the light in which images are shot [2-4]. Though there are number of components affecting the quality of the image but no doubt, a good quality image is the outcome of a good light source [5]. Most of the people consider daylight as a good source for capturing good quality pictures but it is usually not suited for enlightening a scene for digital image processing [4-5]. The effect of colour and intensity of light varies with the orientation of Sun, the time of the year and also the weather conditions and so does the quality of images captured at that instant [5-10]. Contrast and the brightness/intensity are the two basic factors affecting the quality of digital images [8-15]. Quantity of colour or grayscale differentiation existing between different image objects/features in the images is the contrast [16]. It is the difference in the luminance and colour of the image that makes the objects more distinguishable [15-17]. The various objects present in an image are more clearly visible due to the inconsistency in colour and brightness of the object and the other objects in the same scene [18-21]. A lower contrast image displays a smaller degree of colour or grayscale variation than those of higher contrast images and vice versa [20-25]. In other words, the contrast of the digital images can be coined as the RGB intensity (grayscale) of the picture. The specification of the camera used for capturing the information/image also regulates the contrast [26]. Red, green and blue are the three basic components of any coloured image and each component has its own grayscale consisting of varying brightness level for each colour [27]. The other factor affecting the digital images is brightness [28]. Brightness or intensity of the digital image is the intensity of each and every pixel that constitutes the digital image after it has been captured with the camera [25-28]. Pixel brightness or intensity is a vital component of digital images, because (other than colour) it is the only variable that can be utilized by various processing techniques to quantitatively adjust the brightness of the image or the parameters of the image [27-29]. It is a feature of visual sensitivity stimulated by the luminance of the optical object. Brightness can be scaled in terms of colour brightness and grayscale brightness [15-17,19]. Colour brightness represents colour light output and grayscale brightness represents white light output [21,29]. When colour brightness is high, the images will look sharp and good, otherwise dull and dark [14-19,29-30]. The quality of images is a function of brightness, contrast and sharpness. Genetic algorithm was employed for enhancing the quality of dark images based on the genes consisting of parameters brightness, contrast and sharpness. The analysis revealed that the brightness and contrast are the two main factors for quality of images [33]. We had investigated the factors further. In this paper we have studied the effect of changing contrast and brightness on the digital images and have analysed the period of a particular day for which the values of contrast and brightness are high and low and also the impact of orientation of Sun on it. The mathematical aspects are discussed in the next section followed by methodology and results/discussions in the subsequent sections.

2. MATHEMATICAL ASPECTS

A computer display system and the human eyes evaluate the images are at the end of a digital image processing unit. Valuable information is passed to the brain of viewer by the fusion of these two machineries and the viewer is able to study the information in the images more precisely [3,24]. When contrast, chrominance, luminance of the computer display matches to human display (eyes), maximum information transfer is achieved by the human brain [24,26] but this technique consumes a lot of time, so automatic assessment using some particular algorithm will make our work easier. So, we had assessed the digital images in terms of contrast, brightness [31,32,33].

2.1 Normalized Brightness Parameter

Let μ_n be the normalized brightness parameter, then, for grey scale images, normalized brightness parameter can be evaluated as

$$\mu_n = \begin{cases} \dfrac{\mu}{255} & \text{for } \mu < 154 \\ 1 - \dfrac{\mu}{255} & \text{otherwise} \end{cases} \tag{1}$$

A region is considered to have adequate brightness for $0.4 \leq \mu_n \leq 0.6$ [31,32].

2.2 Normalized Contrast Parameter

The normalized intensity parameter (σ_n) can be given as

$$\sigma_n = \begin{cases} \dfrac{\sigma}{128} & \text{for } \sigma \leq 64 \\ 1 - \dfrac{\sigma}{128} & \text{otherwise} \end{cases} \tag{2}$$

A region is considered to have enough contrast when $0.25 \leq \sigma_n \leq 0.5$. For, $\sigma_n < 0.25$, the region has poor contrast and $\sigma_n > 0.5$, the region has too much contrast [31] [32].

3. METHODOLOGY

The effect of the contrast and brightness with respect to time and the orientation of Sun was studied [34]. Brightness and Contrast were taken as the mean and standard deviation [31] [32]. The set of images were taken from a 9.1 mega pixel camera on a Sunny day from morning to evening after regular intervals with the help of tripod attached to the camera so that position and angle of the camera remained intact throughout the process of capturing images. The images were taken in North, South, East and West directions from morning 06:50 am to evening 06:50 pm on 22nd March, 2013 at 32^{O}43’48’’N, 74^{O}52’12’’E. The images were resized to 500 X 500 pixels for reducing the pre-processing steps and computational load. Contrast signifies the RGB intensity of the image, and hence the contrast for each colour of the image was noted by isolating that particular colour with the help of an algorithm developed. The brightness for the image was noted by converting the image to grayscale and isolating each basic colour. Each image after being resized was converted to the desired scale. Each image was divided into 100 sub blocks and contrast and brightness for each block was noted. The average contrast and brightness for each image was noted by taking the average of 100 blocks. The contrast of R, G, B and grayscale was noted and its analysis was done w.r.t. time in North, South, East and West direction and a similar analysis was carried for the brightness of the image. Fig. 1 shows the sequential steps involved in an algorithm in the form of flow chart. Fig. 1 shows flowchart and Figs. 2 to Fig. 5 shows the optical images shot in East, West, North and South directions at 06:50 am in the morning and the same set of images were shot till 18:50 in the evening after regular intervals of time.

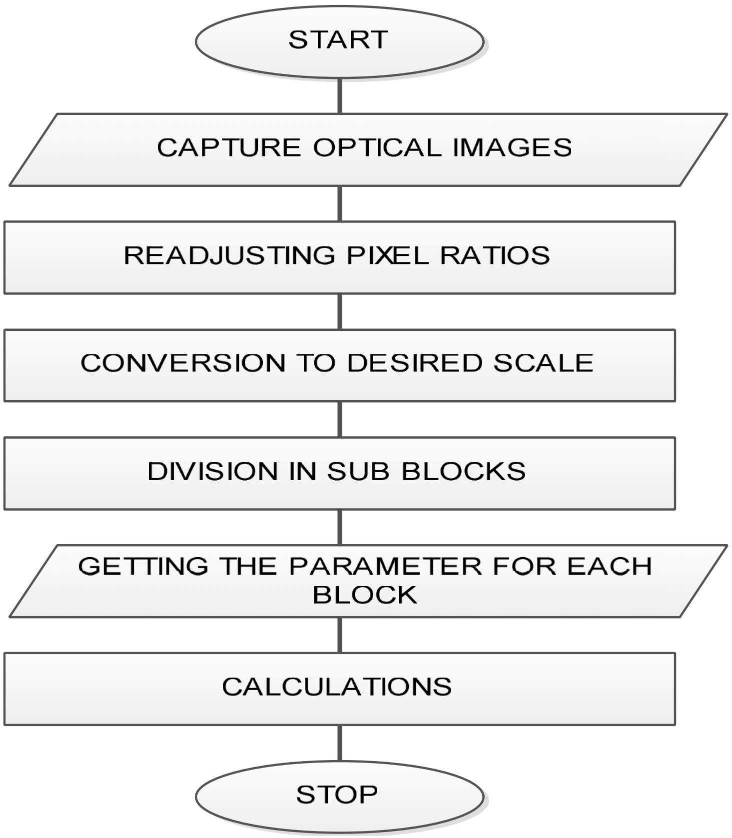

Fig. 1. Steps of the analysis

Fig. 2. Image taken in East direction

Fig. 3. Image taken in West direction


Fig. 4. Image taken in North direction **Fig. 5. Image taken in South direction**

4. RESULTS AND DISCUSSION

The analysis of the brightness and contrast of the digital images is carried out by isolating each basic colour w.r.t time and orientation.

4.1 Analysis of Brightness

Brightness of the image is given in graphical form in Fig. 6 to Fig. 9 and in tabular forms in Tables 1 to Table 4. The red, green and blue component of the image is isolated for analysing the effect of brightness on each colour in every direction. In every direction, the brightness effect for green increases in the morning and after midday it goes on decreasing. For the green component same effect is visualised. But for the blue component the brightness goes on increasing in the morning and after mid-day it goes on decreasing but after sunset, the effect of brightness of blue component shows a hike. In the north direction the brightness during a particular time of the day shows a zigzag pattern due to the fact that the sky was little overcast with clouds. On the average, if we consider the effect of brightness on the image by considering all the colours, it is pertinent to mention here that that the brightness initially increases and then finally decrease after a particular period of day. For the grayscale image same impact is analysed. By isolating blue, the average value of brightness stands at 0.55, 0.53, 0.54, and 0.53 with respect to East, West, North and South direction. The maximum brightness of 0.59 is obtained around 12:50 in the east direction and the minimum value of 0.45 is obtained around 06:50 in the morning in the east direction for the blue component. For the red component the average value of brightness stands at 0.53, 0.49, 0.52, and 0.50 for East, West, North and South direction. The maximum brightness of 0.59 is obtained around 13:50 in the east direction and the minimum brightness of 0.31 is obtained around 18:50 in South direction. The average value of the brightness by isolating green colour stands at 0.55, 0.52, 0.54 and 0.53 in East, West, North and South direction. The maximum and minimum values of 0.59 and 0.44 are obtained in the east and south direction at 13:50 and 18:50 respectively. In the last, if we analyse the grayscale brightness of the image, the average value stands at 0.54, 0.51, 0.53, and 0.52 for east, west, north and south direction. The maximum brightness is obtained in the east direction at around 13:50 and minimum value in west direction at 18:50. The maximum and minimum value stands at 0.59 and 0.41 for grayscale image.

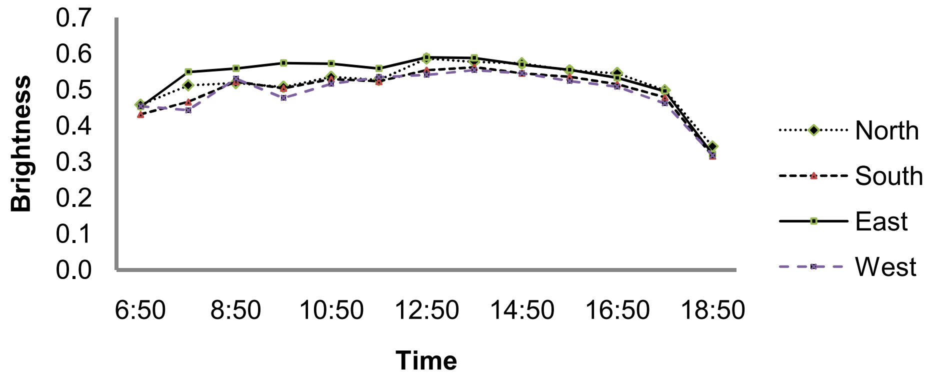

Fig. 6. Brightness by isolating red

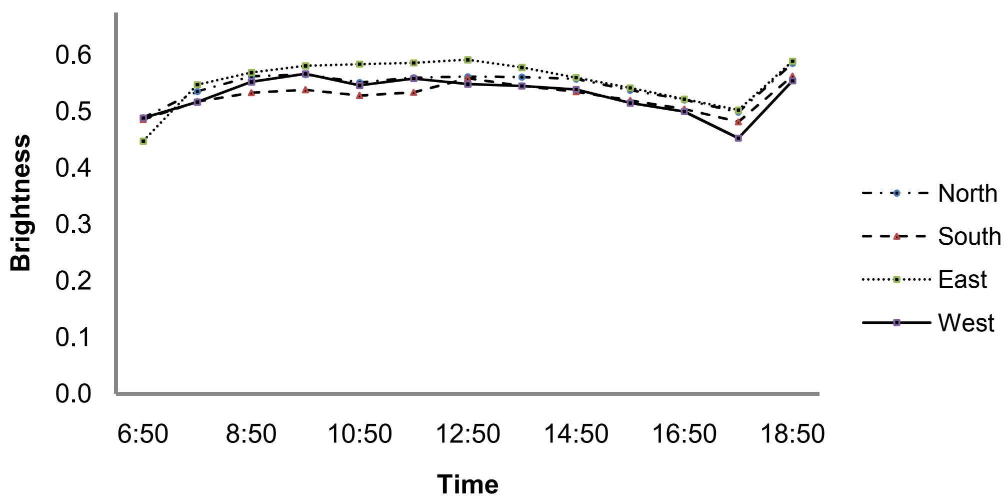

Fig. 7. Brightness by isolating blue

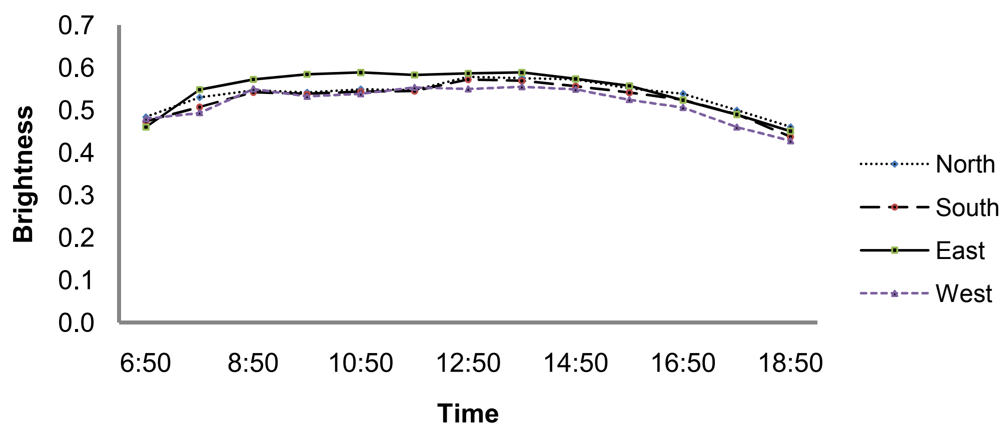

Fig. 8. Brightness by isolating green

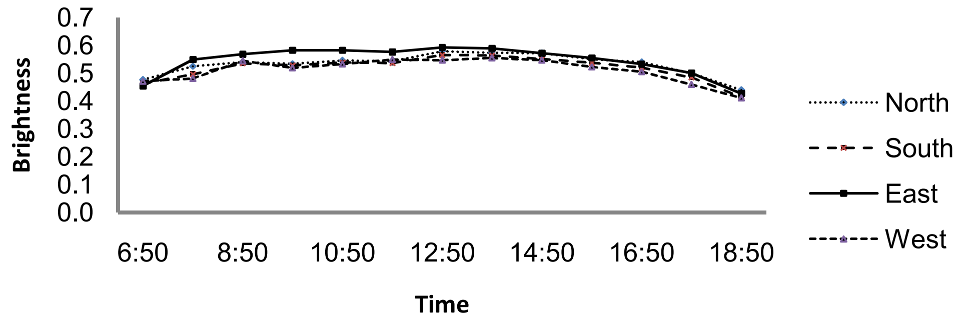

Fig. 9. Brightness for grayscale image

4.2 Analysis of Contrast

The contrast is presented in graphical form in Fig. 10 to Fig. 13 and in tabular forms in Tables 5 to Table 8. The contrast of the digital images shows a zigzag pattern. The average value of contrast stands at 0.03 for every component of the colour in every direction except for the contrast of the red component in east direction. The maximum value of contrast for red component stands at 0.044 at 12:50, 0.033 at 07:50, 0.0422 at 14:50, 0.037 at 08:50 in north, south, east and west direction respectively. The maximum value for green component stands at 0.042 at 11:50, 0.031 at 09:50, 0.042 at 14:50, 0.033 at 17:50 in north, south, east and west direction. The maximum value for blue component stands at 0.040 at 11:50, 0.032 at 18:50, 0.040 at 14:50, 0.031 at 17:50 in north, south, east and west direction. For the grayscale image the maximum value stands at 0.042 at 11:50 & 12:50, 0.031 at 07:50, 08:50 & 09:50, 0.042 at 14:50 and 0.034 at 17:50 in north, south, east and west direction. The contrast values show a slight hike in day time. The contrast in the north and the east direction shows a hike in its values during day time. For simplicity, we have presented the details up to three decimal places. There is a little variation in the contrast for each colour. The grayscale images also follow the same pattern. All the colours follows the same pattern of increase and decrease in the contrast values expect for the blue which shows a rise in contrast value after Sunset. There is very slight difference in the contrast of the images for each colour. On rounding off the contrast to one decimal place, the contrast comes out to be zero. The average contrast value stays out to .03 for all components and with respect to all directions.

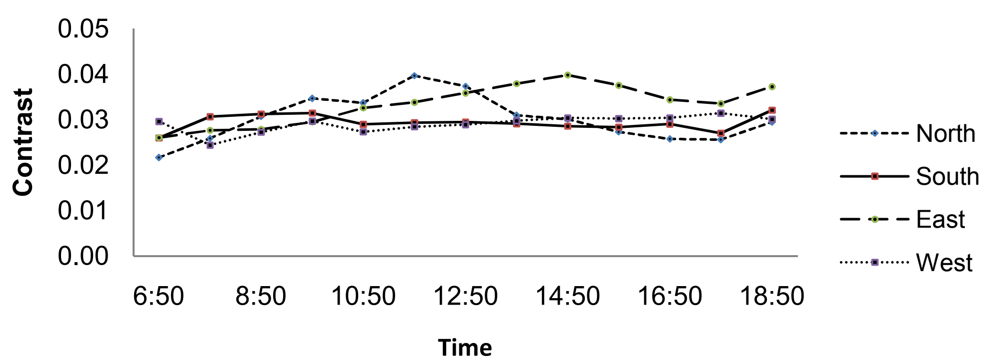

Fig. 10. Contrast by isolating blue

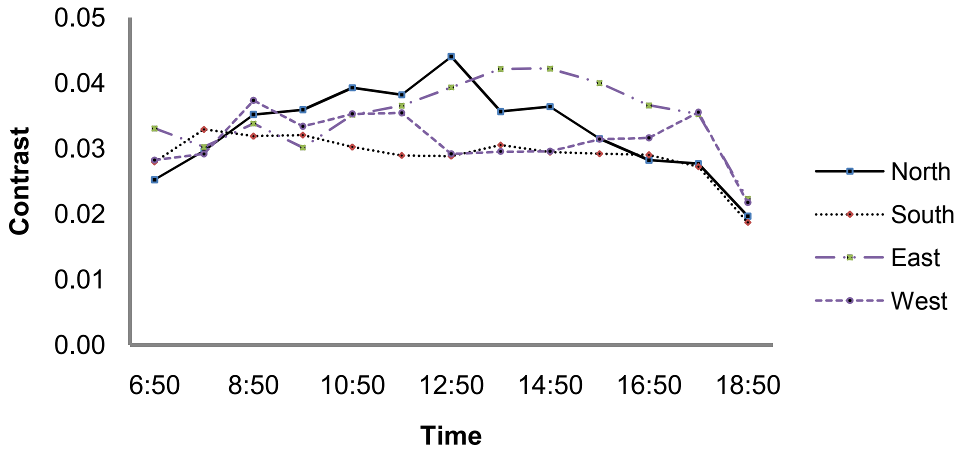

Fig. 11. Contrast by isolating red

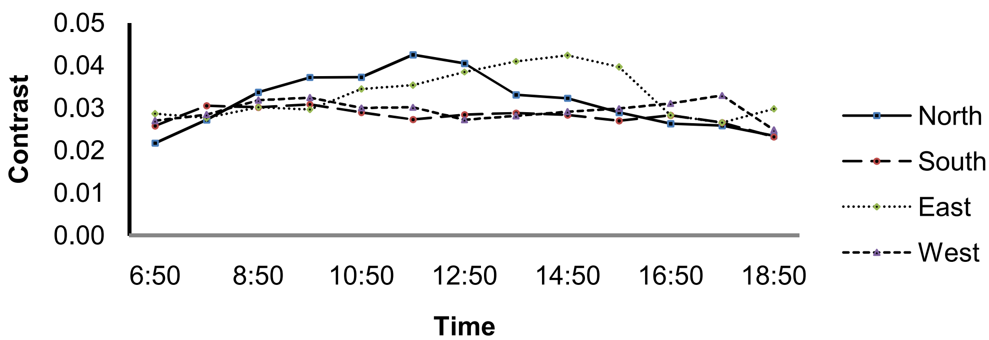

Fig. 12. Contrast by isolating green

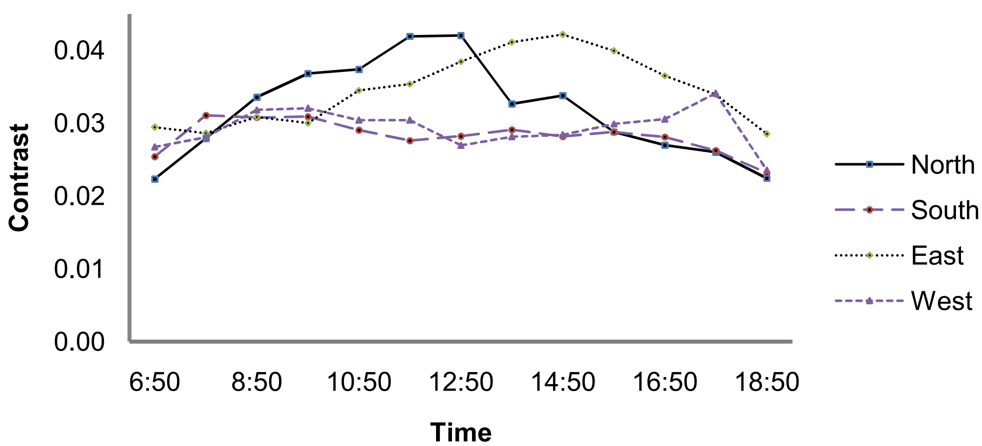

Fig. 13. Contrast for grayscale image

Table 1. Brightness for blue component of the Image

Time	North	South	East	West
06:50	0.49	0.49	0.45	0.49
07:50	0.54	0.52	0.55	0.52
08:50	0.56	0.53	0.57	0.55
09:50	0.57	0.54	0.58	0.57
10:50	0.55	0.53	0.58	0.55
11:50	0.56	0.53	0.59	0.56
12:50	0.56	0.56	0.59	0.55
13:50	0.56	0.54	0.58	0.55
14:50	0.56	0.53	0.56	0.54
15:50	0.54	0.52	0.54	0.51
16:50	0.52	0.50	0.52	0.50
17:50	0.50	0.48	0.50	0.45
18:50	0.59	0.56	0.59	0.55

Table 2. Brightness for red component of the Image

Time	North	South	East	West
06:50	0.46	0.43	0.45	0.45
07:50	0.51	0.47	0.55	0.44
08:50	0.52	0.52	0.56	0.53
09:50	0.51	0.50	0.57	0.48
10:50	0.54	0.53	0.57	0.52
11:50	0.53	0.52	0.56	0.54
12:50	0.59	0.55	0.59	0.54
13:50	0.58	0.56	0.59	0.55
14:50	0.57	0.55	0.57	0.55
15:50	0.55	0.53	0.56	0.52
16:50	0.55	0.51	0.53	0.51
17:50	0.50	0.48	0.50	0.46
18:50	0.34	0.32	0.32	0.32

Table 3. Brightness for green component of the Image

Time	North	South	East	West
06:50	0.48	0.47	0.46	0.48
07:50	0.53	0.51	0.55	0.49
08:50	0.55	0.54	0.57	0.55
09:50	0.54	0.54	0.58	0.53
10:50	0.55	0.54	0.59	0.54
11:50	0.55	0.55	0.58	0.55
12:50	0.58	0.57	0.59	0.55
13:50	0.58	0.57	0.59	0.56
14:50	0.57	0.56	0.57	0.55
15:50	0.55	0.54	0.56	0.52
16:50	0.54	0.52	0.52	0.51
17:50	0.50	0.49	0.49	0.46
18:50	0.46	0.44	0.45	0.43

Table 4. Brightness for grayscale Image

Time	North	South	East	West
06:50	0.48	0.46	0.45	0.47
07:50	0.53	0.50	0.55	0.48
08:50	0.54	0.54	0.57	0.54
09:50	0.53	0.53	0.58	0.52
10:50	0.55	0.54	0.58	0.53
11:50	0.54	0.54	0.58	0.55
12:50	0.58	0.57	0.59	0.55
13:50	0.57	0.56	0.59	0.55
14:50	0.57	0.55	0.57	0.55
15:50	0.55	0.54	0.56	0.52
16:50	0.54	0.52	0.53	0.51
17:50	0.50	0.49	0.50	0.46
18:50	0.44	0.41	0.43	0.41

Table 5. Contrast for blue component of the Image

Time	North	South	East	West
06:50	0.02	0.03	0.03	0.03
07:50	0.03	0.03	0.03	0.02
08:50	0.03	0.03	0.03	0.03
09:50	0.03	0.03	0.03	0.03
10:50	0.03	0.03	0.03	0.03
11:50	0.04	0.03	0.03	0.03
12:50	0.04	0.03	0.04	0.03
13:50	0.03	0.03	0.04	0.03
14:50	0.03	0.03	0.04	0.03
15:50	0.03	0.03	0.04	0.03
16:50	0.03	0.03	0.03	0.03
17:50	0.03	0.03	0.03	0.03
18:50	0.03	0.03	0.04	0.03

Table 6. Contrast for red component of the Image

Time	North	South	East	West
06:50	0.03	0.03	0.03	0.03
07:50	0.03	0.03	0.03	0.03
08:50	0.04	0.03	0.03	0.04
09:50	0.04	0.03	0.03	0.03
10:50	0.04	0.03	0.04	0.04
11:50	0.04	0.03	0.04	0.04
12:50	0.04	0.03	0.04	0.03
13:50	0.04	0.03	0.04	0.03
14:50	0.04	0.03	0.04	0.03
15:50	0.03	0.03	0.04	0.03
16:50	0.03	0.03	0.04	0.03
17:50	0.03	0.03	0.04	0.04
18:50	0.02	0.02	0.02	0.02

Table 7. Contrast for green component of the Image

Time	North	South	East	West
06:50	0.02	0.03	0.03	0.03
07:50	0.03	0.03	0.03	0.03
08:50	0.03	0.03	0.03	0.03
09:50	0.04	0.03	0.03	0.03
10:50	0.04	0.03	0.03	0.03
11:50	0.04	0.03	0.04	0.03
12:50	0.04	0.03	0.04	0.03
13:50	0.03	0.03	0.04	0.03
14:50	0.03	0.03	0.04	0.03
15:50	0.03	0.03	0.04	0.03
16:50	0.03	0.03	0.03	0.03
17:50	0.03	0.03	0.03	0.03
18:50	0.02	0.02	0.03	0.02

Table 8. Contrast for grayscale Image

Time	North	South	East	West
06:50	0.02	0.03	0.03	0.03
07:50	0.03	0.03	0.03	0.03
08:50	0.03	0.03	0.03	0.03
09:50	0.04	0.03	0.03	0.03
10:50	0.04	0.03	0.03	0.03
11:50	0.04	0.03	0.04	0.03
12:50	0.04	0.03	0.04	0.03
13:50	0.03	0.03	0.04	0.03
14:50	0.03	0.03	0.04	0.03
15:50	0.03	0.03	0.04	0.03
16:50	0.03	0.03	0.04	0.03
17:50	0.03	0.03	0.03	0.03
18:50	0.02	0.02	0.03	0.02

5. CONCLUSION

Analysis of red, green and blue component and grayscale image has shown that the brightness effect for all the components except for the blue follow a same pattern. Throughout the day, only for some time the brightness fulfils the criteria [31,32]. Only for a specific period of the day, the brightness is supposed to help in producing good quality images. It is concluded that the contrast does not satisfy the criteria [31,32] mentioned in equation 2. So, a mere shooting image in Sunlight is not the only necessity of good image processing. Though brightness changes with the position of Sun but the contrast shows a slight change in its value. It means that the position of Sun has hardly to do anything with the contrast. So, outdoor photography is suited if only brightness is to be considered but for contrast some other measures are to be used to enhance the quality of images i.e. to capture good quality images. Contrast and brightness are the two main factors that affect the quality of images and here we had studied its behaviour on a Sunny day a little bit overcast with clouds. In our smartphones and other devices the orientation and position of sun effects the quality of images i.e. the brightness. The altitude, latitude and longitude of the particular place effects the quality of the images in terms of brightness. If the investigations for the same are carried at different places, the data can be used for removing the illumination problem from the smartphones. Now how to improve the contrast and brightness of the images with respect to different weather conditions, longitude and latitude of the place is in our future leaflet.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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