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Qualitative and Quantitative Analysis of Non-Uniform Dark Images

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ABSTRACT

In this paper, an algorithm is developed to attain information from the dark images and an analysis is sought for the impact of brightness adjustment parameter (α) and color hue (λ) on a single dark image. The algorithm appears quite appealing as the quality of the images become clearer. This algorithm is applied on a single dark image for different values of α and λ and out of resultant twenty four images; medium, high and low quality were selected randomly for mean opinion score. A mean score opinion (MOS) is drawn for a set of processed and unprocessed images and the results gathered shows that the processed image gathers valuable information and appeared clear. Results showed that few parts where no information was being noticed before processing the digital image, now provides information to the subject after processing..

Keywords: Digital image processing, enhancement, image quality, MOS, image analysis.

1. INTRODUCTION

Digital image processing possess their application in intelligent transportation systems such as automatic number plate recognition, traffic sign recognition, weather forecasting, and in medical field for diagnosis of diseases, satellite systems, remote areas , space research etc [1]. The high quality of an image is the prime requirement and is possible to obtain using image enhancement techniques. There is no such theory of image enhancement. It's a visual perception [2] [3]. Several enhancement techniques exist and few of them work on dark images and some on day light images. Thus the field of image enhancement techniques provides a significant ways to modify specific set of images suitable for the concerned user [4]. Image enhancement is the method to enhance the quality of images in term of contrast, brightness and sharpness [5-8]. The objective of image enhancement is to enhance the image so that the processed image is more suitable for a particular set of application [2-4] [9-23]. Enhancing the digital image can be done in various ways [24]. All depends upon the viewer's perception or

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interpretability to access the image [2] [25]. Some applications require removing the noise and in others may be brightening the dark images are the prime requirement. Researchers had classified the image enhancement techniques into two categories; Spatial domain methods and frequency domain methods [2-3] [15] [18] [22-23] [26-29] [30-32].

Spatial domain refers to the aggregate of pixels composing an image, i.e., pixel values are manipulated to obtain a better enhanced image. It directly deals with changing the individual pixel values and hence the contrast value of the whole image [15] [18]. The frequency domain method deals with the manipulation of the orthogonal transform of the image i.e., it deals with the image indirectly. Magnitude and phase are the main components of orthogonal transform [20] [22] [23]. Magnitude deals with the frequency content and phase is to restore the image back to the spatial domain. All the image enhancement operations are carried on the Fourier transform of the image and then the inverse Fourier transform is carried to obtain the resultant image [2-3] [20] [22-23] [26-28] [30-33].

Though a number of techniques exist for colour image enhancement, we in this paper, concentrated on image enhancement of dark images only. The dark images can be brightened by power law transformations or log transformations. The power law transformation expands the gray level thus capturing information from dark regions whereas the log transformations brighten the dark regions at the expense of brighter region information [2-3] [20] [22-23] [26-28] [30-32]. Here we have used the enhancement technique purposed by Sertan Erkanli et al for capturing information from the low quality images [34-36]. They proposed the enhancement technique for non-uniform and uniform dark images (ETNUD).

2. TRANSFORMATION PARAMETERS

According to Sertan Erkanli et al, the intensity *I* of the color image is provided by the equation *I*(*m,n*) and is given as

$$I(\mathrm{m,n}) = 0.2989\mathrm{R}(\mathrm{m,n}) + 0.587\mathrm{G}(\mathrm{m,n}) + 0.114\mathrm{B}(\mathrm{m,n})$$

where R, G, B are the red, green and blue components of the color image. For *I* having 8-bits per pixel, I_n is the normalized version of *I*, such that

$$I_{\mathrm{n}}(\mathrm{m,n}) = \frac{I(\mathrm{m,n})}{255}$$

Researchers analyzed that the linear input-output intensity relationships does not provide good visual perception as compared to that of direct viewing of the scene. To get a better perception, nonlinear transformation for dynamic range compression is used.

Several enhancement methods are based on center/surround ratios. Gaussian form is one such method to produce good dynamic range compression. The luminance of surrounding pixels using 2D discrete spatial convolution with a Gaussian kernel is given as,

$$G(m,n) = K \exp\left(-\frac{m^2+n^2}{\sigma_s^2}\right)$$

where σ_s is the surround space constant equal to the standard deviation of $G(m,n)$ and K is determined under constraint that $\sum_{m,n} G(m,n) = 1$.

An adaptive contrast enhancement parameter (S) related to the global deviation of the input intensity image, $I(m,n)$, and '*' as the convolution operator, is defined as

$$S = \begin{Bmatrix} 3 \;\; for \;\; \sigma \le 7 \\ 1.5 \;\; for \;\; 7 < \sigma \le 20 \\ 1 \;\; for \;\; \sigma \ge 20 \end{Bmatrix}$$

σ is the contrast- standard deviation of the original intensity image. If $\sigma<7$, the image has poor contrast and contrast of the image will be increased. If $\sigma \ge 20$ the image has sufficient contrast. These are the factors responsible for the enhancement of the information or images or in other words refining the digital image. The quality of the digital image can be calculated as

$$Q = 0.5\mu_n + 0.4\sigma_n + 0.1S$$

where μ_n is the normalized brightness parameter, σ_n is the normalized contrast parameter, and S, the sharpness.

Table 1. Quality of processed images for different combinations of α and λ.

α	λ										
0.00	0.15	0.25	0.35	0.45	0.50	1.00	2.00	3.00	4.00	6.00	7.00
-0.80	0	0	0	0	0	0	1	1	1	1	1
-0.75	0	0	0	0	0	0	1	1	1	1	1
-0.70	0	0	0	0	0	0	1	1	1	1	1
-0.65	0	0	0	0	0	1	1	1	1	1	1
-0.60	0	0	0	0	0	1	1	1	1	1	1
-0.55	0	0	0	0	0	1	1	0	0	0	0
-0.50	0	0	0	0	0	1	0	0	0	0	0
-0.45	0	0	0	0	1	1	0	0	0	0	0
-0.40	0	0	0	0	1	1	0	0	0	0	0
-0.35	0	0	0	1	1	1	0	0	0	0	0
-0.30	0	0	0	1	1	1	0	0	0	0	0
-0.25	0	0	0	1	1	1	0	0	0	0	0
-0.20	0	0	0	1	1	0	0	0	0	0	0
-0.15	0	0	0	1	1	0	0	0	0	0	0
-0.10	0	0	1	1	1	0	0	0	0	0	0
-0.05	0	0	1	1	1	0	0	0	0	0	0
0.00	0	0	1	1	1	0	0	0	0	0	0
0.05	0	0	1	1	1	0	0	0	0	0	0
0.10	0	0	1	1	1	0	0	0	0	0	0
0.15	0	0	1	1	1	0	0	0	0	0	0
0.20	0	0	1	1	1	0	0	0	0	0	0
0.25	0	0	1	1	1	0	0	0	0	0	0
0.30	0	0	1	1	1	0	0	0	0	0	0
0.35	0	0	1	1	1	0	0	0	0	0	0
0.40	0	0	1	1	1	0	0	0	0	0	0
0.45	0	0	1	1	1	0	0	0	0	0	0
0.50	0	0	1	1	1	0	0	0	0	0	0
0.55	0	0	1	1	1	0	0	0	0	0	0
0.60	0	0	1	1	1	0	0	0	0	0	0
0.65	0	1	1	1	1	0	0	0	0	0	0
0.70	0	1	1	1	1	0	0	0	0	0	0
0.75	0	1	1	1	1	0	0	0	0	0	0
0.80	0	1	1	1	1	0	0	0	0	0	0

3. METHODOLOGY

An image taken in dark provides little information or no information at all. The proposed algorithm refined the information present in the dark area. The evaluation criterion starts by taking a single dark image and then processing for different values of α and λ. More than 350 images were processed for different combinations of α and λ. The quality of the processed and unprocessed images was evaluated by resizing and selecting random pixel points of the image. For some processed images, the quality shows a high value but the picture clarity was poor. The reason is that the quality is controlled by three parameters contrast (σ), brightness (μ) and sharpness (S). The value of μn should lie between 0.4 and 0.6. If this value alters, the quality value becomes numerically high but not visually. That's why in certain cases, the quality shows high calculated value but not visually. Similarly, the contrast value should lie between 0.25 and 0.5.

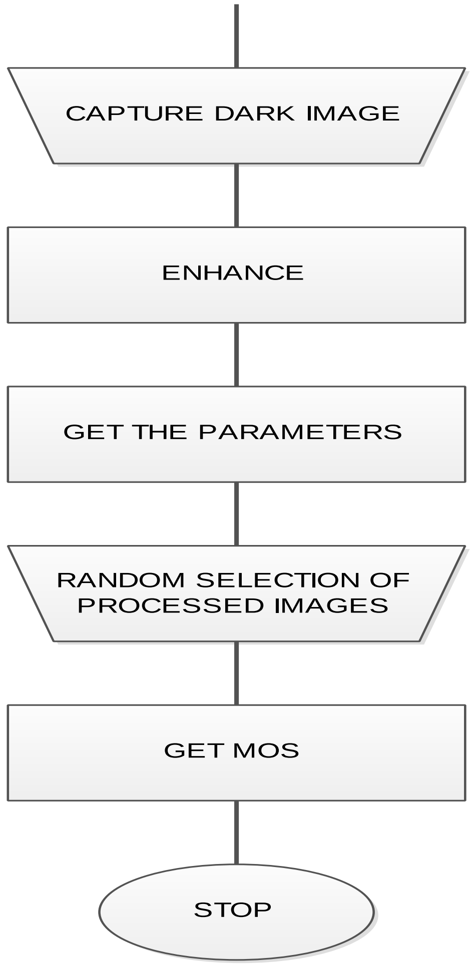

Figure 1: Flow chart showing the process to check for the MOS for assessment of the quality.

A random selection of 24 processed images was made besides one unprocessed image. Out of them, 8 were of high quality, 8 of low and 8 of medium quality. These images were then randomly selected and assessed for the quality of the digital images by ten different subjects. The subjects were unaware of the original and the processed images. Corresponding to each image, the marks out of ten were given by the subjects to the image. In other words, the mean score opinion (MOS) was noticed for each image. The average marks given by the ten evaluators were calculated and correspondingly quality and standard deviation is noticed. The results show interesting features.

The images were taken by 9.1 mega pixel digital camera in the evening time. About 50 different dark images were clicked and out of them, one with the darkest of all was selected to carry out the experiment. The selected image contained all the three primary colors shown in fig. 2.

Figure 2: Unprocessed Dark image.

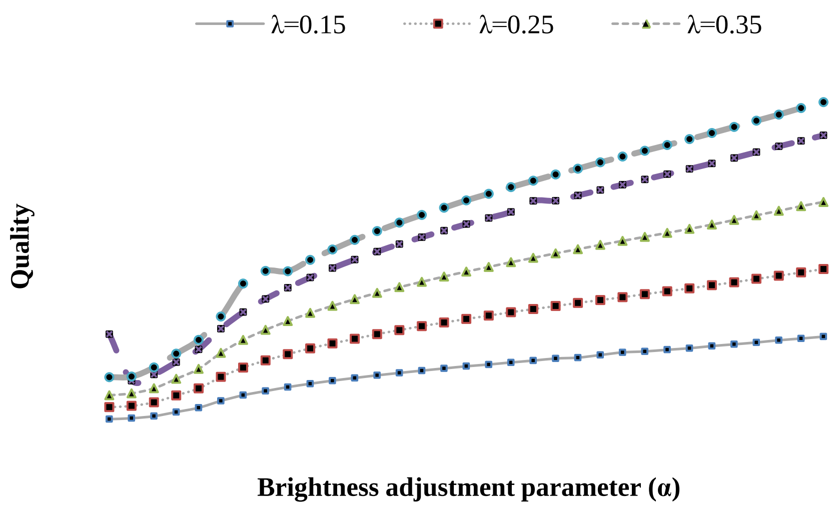

Figure 3: Quality curve for fractional values of λ.

The image has a quality factor of 0.3422 and a standard deviation of 0.002. A careful visual observation shows some missing information in the lower part of the image. This image is processed 385 times for different combinations of α and λ. Table 1 shows the processed quality results. The 0's in the table signifies that the images having quality lower than the original image and for 1's higher is the quality. The corresponding graphs are drawn for two set of λ; one having fractional values and other having integer values. The images corresponding to $\lambda \leqslant 0$ were not processed as they provide no information at all. Fig. 3 shows the graph for fractional values of λ. The alpha is taken from -0.80 to 0.80 with an auto increment of 0.05. As we go on increasing the α and λ the quality shows a hike in its values for fractional λ. Fig. 4 shows the graphs for integer values.

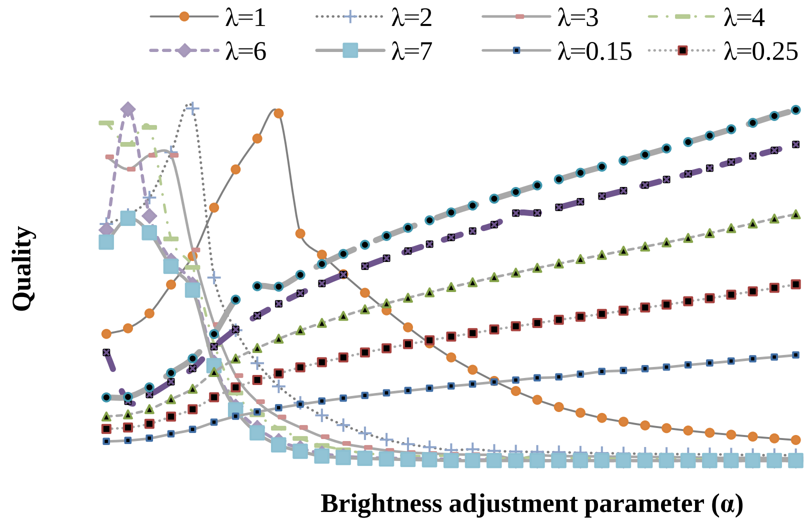

Figure 4: Quality curve for integer values of λ.

Here the results are quite interesting but opposite to that of the fractional λ. With the increase in α, the quality also shows an increase up to a certain value and then decreases in its value which saturates at about 0.2. This is impossible to show all the twenty four processed images. Fig. 5, Fig. 6, Fig. 7, and Fig. 8 shows the processed images out of 24 randomly selected images for MOS.

Figure 5: Processed image having α = -0.1 and λ = 1.

Table 2. Quality and standard deviation of 24 randomly selected images for MOS.

α	λ															
	0.25		0.35		0.45		0.50		1.00		2.00		3.00		4.00	
	Q	SD	Q	SD	Q	SD	Q	SD	Q	SD	Q	SD	Q	SD	Q	SD
-0.45											0.2853	0.0024			0.2401	0.0025
-0.40									0.5038	0.0020			0.2290	0.0022	0.2284	0.0020
-0.35											0.2505	0.0024				
-0.25							0.3809	0.0007	0.3630	0.0016						
-0.20							0.3889	0.0006	0.3468	0.0016						
-0.15							0.3966	0.0007								
-0.10							0.4037	0.0007	0.3166	0.0014						
-0.05			0.3473	0.0004			0.4103	0.0006								
0.00	0.3085	0.0003	0.3519	0.0004												
0.05					0.4009	0.0005	0.4231	0.0006	0.2794	0.0011						
0.10			0.3605	0.0003												
0.20			0.3686	0.0003	0.4167	0.0003										
0.30			0.3763	0.0002												

Figure 6: Processed image having α = 0 and λ = 0.35

Table 3. Mean opinion score (MOS) given by 10 different users.

SUBJECTS	PROCESSED IMAGES																								ORIGINAL IMAGE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	4.0	5.0	4.0	4.0	3.0	2.0	4.0	1.0	0.0	5.0	2.0	3.0	2.0	6.0	4.0	3.0	7.0	8.0	8.0	7.0	6.0	4.0	4.0	5.0	2.0
2	3.0	3.0	3.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	3.0	2.0	2.0	6.0	5.0	6.0	5.0	4.0	2.0	3.0	3.0	2.0
3	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	2.0	1.0	1.0	1.0	2.0	3.0	2.0	3.0	6.0	7.0	5.0	4.0	3.0	2.0	2.0	2.0	2.0
4	3.0	3.0	4.0	3.0	4.0	3.0	3.0	2.0	2.0	4.0	3.0	3.0	2.0	7.0	5.0	4.0	8.0	7.0	7.0	6.0	6.0	5.0	5.0	5.0	2.0
5	4.0	3.0	2.0	3.0	3.0	2.0	4.0	2.0	3.0	5.0	3.0	2.0	3.0	6.0	4.0	4.0	8.0	7.0	8.0	6.0	5.0	4.0	4.0	3.0	2.0
6	4.0	5.0	4.0	4.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	4.0	2.0	7.0	6.0	5.0	7.0	8.0	8.0	9.0	7.0	6.0	5.0	5.0	3.0
7	6.0	6.0	5.0	5.0	4.0	4.0	4.0	3.0	5.0	6.0	5.0	4.0	5.0	8.0	6.0	5.0	8.0	8.0	8.0	8.0	7.0	7.0	7.0	7.0	3.0
8	3.0	4.0	3.0	2.0	2.0	2.0	3.0	1.0	1.0	3.0	1.0	1.0	2.0	5.0	4.0	2.0	8.0	8.0	7.0	8.0	5.0	6.0	4.0	5.0	2.0
9	4.0	3.0	2.0	3.0	2.0	2.0	4.0	2.0	1.0	2.0	2.0	3.0	0.0	4.0	5.0	3.0	9.0	8.0	8.0	7.0	6.0	5.0	4.0	3.0	3.0
10	4.0	2.0	2.0	2.0	1.0	1.0	2.0	0.0	2.0	4.0	4.0	2.0	4.0	4.0	3.0	4.0	8.0	7.0	8.0	7.0	5.0	4.0	4.0	3.0	2.0
MEAN	3.7	3.6	3.0	2.8	2.4	1.9	2.9	1.3	1.8	3.4	2.4	2.4	2.2	5.3	4.1	3.5	7.5	7.3	7.3	6.7	5.4	4.5	4.2	4.1	2.3
STD	1.0	1.2	1.1	1.2	1.1	1.0	1.1	1.0	1.3	1.5	1.4	1.1	1.4	1.6	1.3	1.0	0.9	0.9	1.0	1.4	1.1	1.5	1.2	1.4	0.4

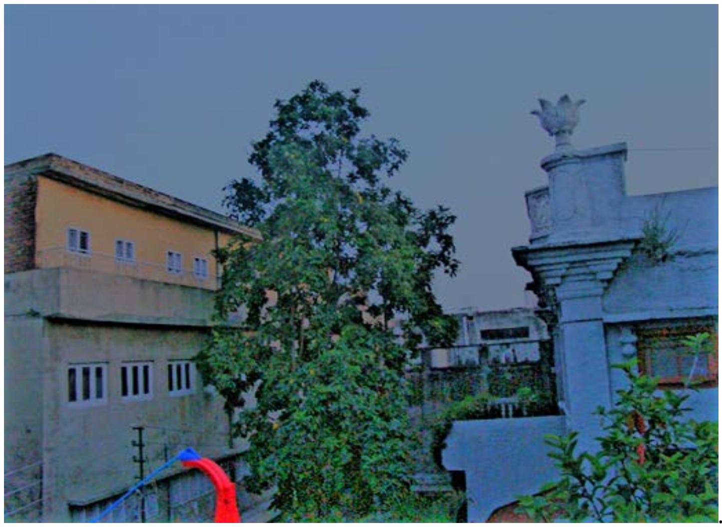

Figure 7: Processed image having α = 0.5 and λ = 0.5

If we compare the processed and original image, this can be noticed that the processed images provide more information to the viewer. In original image no information was there in the dark regions but the processed image refines the information provided in the dark areas.

Table 2 shows the measured quality and standard deviation of 24 randomly selected images after considering the mean opinion score (MOS) from ten subjects for each image. The mean opinion score (MOS) given by the ten subjects/people is shown in Table 3. Each subject rated the processed and unprocessed images as per his opinion and perception. The marks were given out of 10 for each digital image. The results shows that the subjects were not able to distinguish between the processed and the unprocessed or original image.

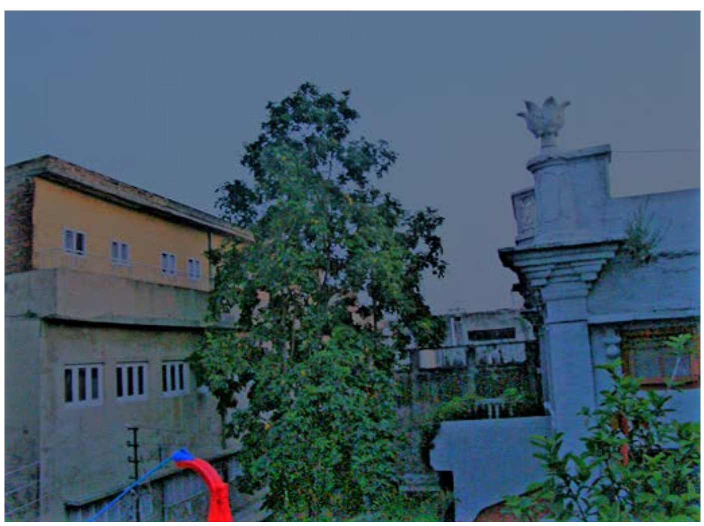

Figure 8: Processed image having α = 0.05 and λ = 0.45

All the subjects rated the original image as poor. The average score given to it by ten subjects were 2.3. The images which were given highest score of all 25 images were 17 to 20. These images were having α=-0.1,0.5,-0.2,0.25 respectively and λ=1 for all the images. The

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image 18 having $\lambda=1$ and $\alpha=0.5$ got the highest average score of all the randomly selected 24 images.

4. CONCLUSION

This technique is suited for dark images while for daylight images, it gets deteriorated. The original dark image provides lesser information but after processing same image provides a lot of information, though quality of color deteriorates a little. The processed images appear as if they were taken in the daylight. The results of MOS show that on the average no one was able to distinguish between the original and processed image. Every subject rated the processed image as the better one. Hence, in this paper we analyzed the results using particular technique to enhance the quality of natural dark images.

Our future work is applying the same technique on the medical scans, i.e., on ultrasound or MRI images and evaluate out experimentally, whether this technique refines the results for medical science or not.

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