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Dynamic Optımızatıon of Image Brıgthness Level With Optimal Gamma Value Assessment (OGVA) Method

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Keywords
Image; Dynamic Intensity; Gamma Correction; Histogram

Abstract

In this study, the proposed Optimum Gamma Value Assignment (OGVA) method is intended to dynamically optimize the image intensity level in non-desired images due to undesired light levels. For this purpose, it is aimed to make the dark images which cannot be seen due to lack of light, while bright images are dynamically dimmed by using the optimum gamma correction value applied on the image momentarily. It has been shown that this novel method, which will only be implemented as software, without requiring any additional hardware, yields satisfying results even at different light levels.

Optimal Gama Değeri Saptama (OGVA) Yöntemi ile Görüntü Parlaklık Seviyesinin Dinamik Optimizasyonu

Anahtar Kelimeler
Görüntü; Dinamik; Parlaklık; Gama düzeltimi; Histogram

Öz

Bu çalışmada, önerilen Optimum Gama Değeri Ataması (OGVA) yöntemi ile istenmeyen ışık seviyeleri içeren görüntülerde görüntü ışık seviyesinin dinamik olarak optimize edilmesi amaçlanmıştır. Bu amaçla ışığın yetersizliğinden dolayı görülemeyen karanlık görüntüler aydınlatılırken, parlak görüntülerin ise anlık olarak uygulanan en iyi gama düzeltme değeri kullanılarak dinamik olarak karartılması amaçlanmaktadır. Herhangi bir ek donanım gerektirmeden sadece yazılım olarak uygulanacak olan bu yeni yöntemin, çok küçük hesaplama maliyeti ile farklı ışık seviyeleri için bile tatmin edici sonuçlar verdiği gösterilmiştir.

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1.Introductıon

Today, all cameras, including surveillance cameras, are used effectively in many areas such as healthcare, traffic monitoring, astronomy and defense industry. However, in many cases, the image quality may not be at the desired level if the amount of light is insufficient or too much glare.

Nowadays, for the purpose of enhancing the images obtained, there are many operations for optimizing the image light by methods such as

filtering the image by high-pass filter (Gonzalez and Woods 2002), histogram equalization (Gonzalez and Woods 2002), or histogram scattering methods (Gonzalez and Woods 2002). However, these processes require either the Fourier transformation of the image and the inverse Fourier transformation after the operations in the frequency domain, or it may cause delays so that it requires a lot of processing power on the basis of pixels in the time space and which may prevent its use in real time video shooting.

(Huanga et. al 2016) are *proposed* a novel image enhancement method improving the contrast of local pixels through adaptive gamma correction (AGC), which is formed by incorporating a cumulative histogram or cumulative sub-histogram into the weighting distribution. However, the proposed method is difficult to implement in a short time and not suitable for real time video applications.

(Yang et. al 2007), proposed a weighted calculation to prevent the unexpected effects appearing and the local bihistogram equalization (LBHE) to reduce the over-enhancing artifacts. However, the proposed method is difficult to implement in a short time and not suitable for real time video applications.

Recently, in a work (Hao et. Al 2020) a low-light image enhancement by semi-decoupled Retinex decomposition During the decomposition process is proposed, where the Retinex image decomposition is achieved in an efficient semi-decoupled way.

In another work (Wu et al. 2019) proposed a novel low light image enhancement method based on the non-uniform illumination prior model and used fast Fourier transform to accelerate the results.

A work by (Sajevu and Babu K.K.,2019), proposes a fusion based method and existing method (BBF) has been modified by repeating the proposed method partially and fully. They achieved the improvement of the contrast to noise ratio by 11 % and 12 % compared to BBF and BBFR respectively.

(Saxena S et all 2016) tried to provide the comparative study for the existing contributions of parallel image processing applications with their benefits and limitations. In that work the CPU elapse times for evaluated images using brightening image transformation for the images with resolutions 256x 256, 512 x 512, 1024 x 1024, 1800 x 1400 and 4000 x 4000 are given.

Even if all these works succeeded in image enhancement either under low visibility or high foggy conditions, the proposed algorithms seem to be usable only after having an input image and implementation of complex and long delayed operations on that image. Thus, it will be very difficult to implement these methods on a camera during the real time recording operation.

However, in this study, it is aimed to optimize the image illuminance level by the proposed Optimal Gamma (γ) Value Assignment (OGVA) method. By this method, a gamma value for the instant image intensity level is adaptively calculated to the image by using average value of all the pixel values of the image. Then the optimized gamma value can be rapidly applied as a single transfer function to the whole image without any pixel based operation. With the proposed Optimum Gamma Value Assignment (OGVA) method, it is intended to have a lightened image in the case of having a dark image, or if the image is too bright, the image will be faded instantaneously where the process will require a low processing load and low delay in both cases.

2.Effects of Gamma Value on Image Intensity Level

Gamma correction method is used by CRT (Cathode Ray Tube) monitors to eliminate unintentional illumination, which is used in image contrast due to the nature of the monitor (Lee and Chan 2005).

The gamma value that will generate the new pixel value (s), from the old one (r) as seen in Figure 1 is generally applied as (Stokes et. al 1996).

$$S = c.r^{\gamma} \qquad (1)$$

Any coefficient (c) value will be applied for the optimization and then it will be optimized into the image intensity level scale. This dynamic correction can also be used, for example, to bring a deleted image on a washed paper into an over-lit image effect, and this will move this image closer to the original with a correct gamma value selection. In eq. 1 , as c and γ are positive coefficients, and r is the original intensity level value of the pixel being studied, the intensity level of the same pixel after the conversion (s) is evaluated. In all cases of this study, the value of c is taken as 1 and the optimum gamma value is tried to be determined in this way. Figure 1 shows transfer functions to be formed for different values used in Gamma correction.

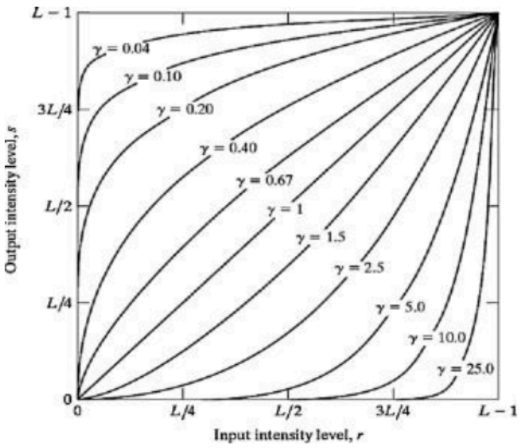

Figure 1. Transfer functions to be formed for different values used in Gamma correction. Gonzalez and Woods 2002)

3.Determination of Optimum value in using OGVA method

It is normally possible only for a human to look at the image and compare it with the normal level of light that an image must have.

On the other hand, it can be said that, although the difference between the minimum and maximum intensity level values of the pixels in an image is higher than a certain threshold value (in this case it is understood that the image has sufficiently bright and dark pixel values), the average intensity level value of the image can be carried to a mean value of overall scale.

In this study, a new method has been proposed for adjusting the gamma value to be applied image while adjusting the intensity level of such images by using gamma correction and starting from the pixel values of the image and performing a calculation without the need of high processing power and high delay.

In this method, if the image is naturally light or dark, taking into account all the pixels of the image. The formula given in eq. 2 is proposed to be applied. With this formula, the gamma value to be used will dynamically be produced using the average intensity level of the image.

The aim here is to draw the average intensity value of an image with a n-bit resolution and 2^n intensity level, to the $2^n / 2$ average expected intensity level, which is the exact center point of the light and dark levels. Normally, gamma value of 1 will have no effect on the image. By obtaining and using the optimum gamma value, the average of the pixel values will be decreased or increased. In both cases the image will be able to bring the average intensity level to L / 2. For this purpose, to generate the desired optimum gamma value the formulas in eqs. 2-4 are used;

$$\gamma = \log_{average}{}^{L/2} \quad (2)$$

$$\gamma = \frac{\log_{10}{}^{\left(\frac{L}{2}\right)}}{\log_{10}{}^{(average)}} \quad (3)$$

$$\gamma = \frac{\log_{10}{}^{\left(\frac{L}{2}\right)}}{\log_{10}{}^{\left(\sum_{k=1}^{N}\sum_{l=1}^{M}\frac{p(k,l)}{N\times M}\right)}} \quad (4)$$

where, L represents the total intensity level of the image, average represents the average intensity value of overall image and p (k, l) is the intensity level of the pixel of k.th row and l.th column, N is the total number of pixels in a column and M is the total number of pixels in a row in the image. In this way, as the new gamma value is determined by eqs.2-4 the average intensity level value of the image is drawn to L / 2. Eqs. 5-7 are used to determine the new values of each pixel,

$$r_{new} = c.r_{old}{}^{\gamma} \quad (5)$$

$$r_{new} = c.r_{old} \log_{\left(\sum_{k=1}^{N}\sum_{l=1}^{M}\frac{p(k,l)}{N\times M}\right)}{}^{\left(\frac{L}{2}\right)} \quad (6)$$

$$r_{new} = c.r_{old}{}^{\frac{\log_{10}{}^{\left(\frac{L}{2}\right)}}{\log_{10}{}^{\left(\sum_{k=1}^{N}\sum_{l=1}^{M}\frac{p(k,l)}{N\times M}\right)}}} \quad (7)$$

In eq. 7, when n is taken as 8 bits/pixel, L will be in 256 range and the intensity level values will range

from 0 to 255 for each pixel at different average overall intensity levels. Figure 2 shows the graph of gamma values that should be applied to the image according to eq.3.

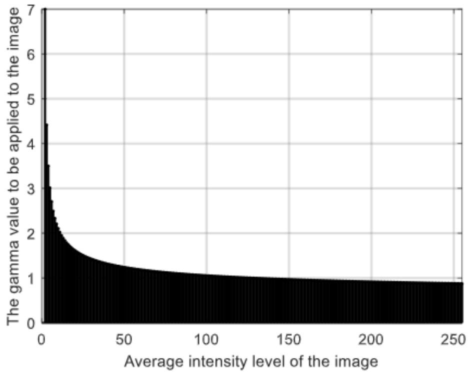

Figure 2. The optimum gamma value to be applied according to the image average intensity value

4.The effects of evaluated Optimum γ value by use of OGVA method, on the image

Figure 4 shows a dark image with insufficient light and when we apply the recommended OGVA method on this image, it is expected that the average intensity level of this image will be equal to 128 for the 255 intensity levels. For this reason, it is expected that the current value of the image will be illuminated by applying new pixel values to the image.

Figure 3. The Original Image

The application of OGVA method to this image which yields the Gamma value as 1.1911, gives the obtained image for figure 3 as in Figure 4

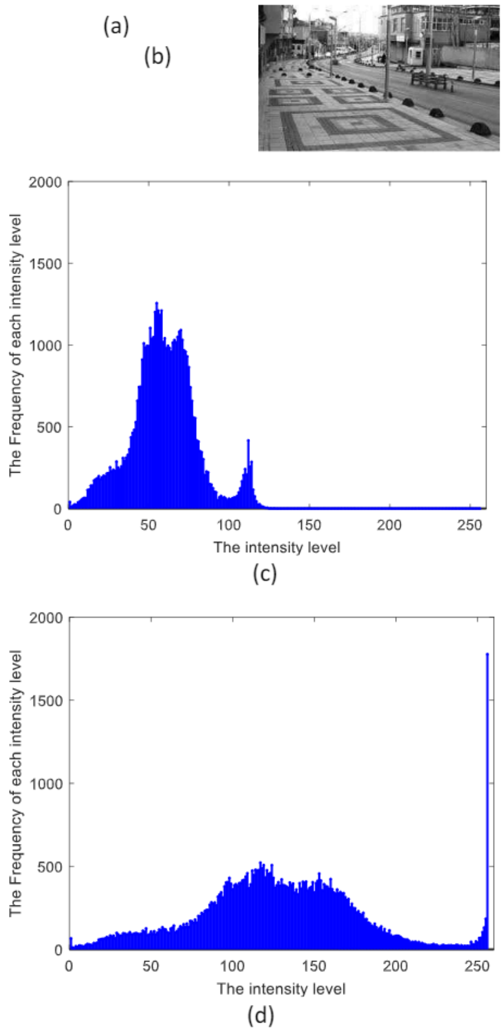

Figure 4. (a) The image to be optimized by OGVA (b) The evaluated image after the application of OGVA by dynamically adjusting the intensity of the image according to image intensity level. (c) The histogram of the image in "a" before applying OGVA (d) The histogram of the image in "b" after applying OGVA

In addition, the application of the OGVA method to the already optimized image according to the image intensity level (with the 0.9983 gamma value found) is shown in Figure 5. It is seen that almost no illumination or dimming is applied by OGVA method on the images it still remains with sufficient intensity levels.

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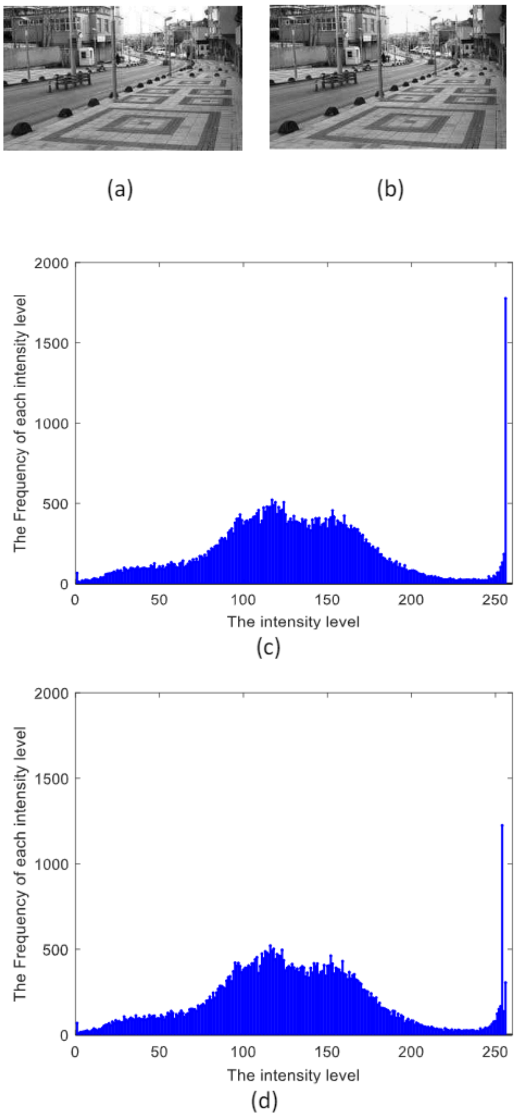

Figure 5. (a) An already optimized image by the application of OGVA method (b) result of application of OGVA method to the already optimized image (c) The histogram of the image in "a" before applying OGVA (d) The histogram of the image in "b" after applying OGVA

In addition, when we apply the OGVA method to a darker image with more insufficient intensity level, the obtained gamma value (gamma = 1.3258) from eq. 3 yields the image given in figure 6, which is very similar to obtained images in other cases.

It is seen from the results given on figure 4 to figure 6 that OGVA method also succeeds in images with different intensity levels and different histograms, by having almost normally distributed and almost same histograms for all cases with different intensity level of images.

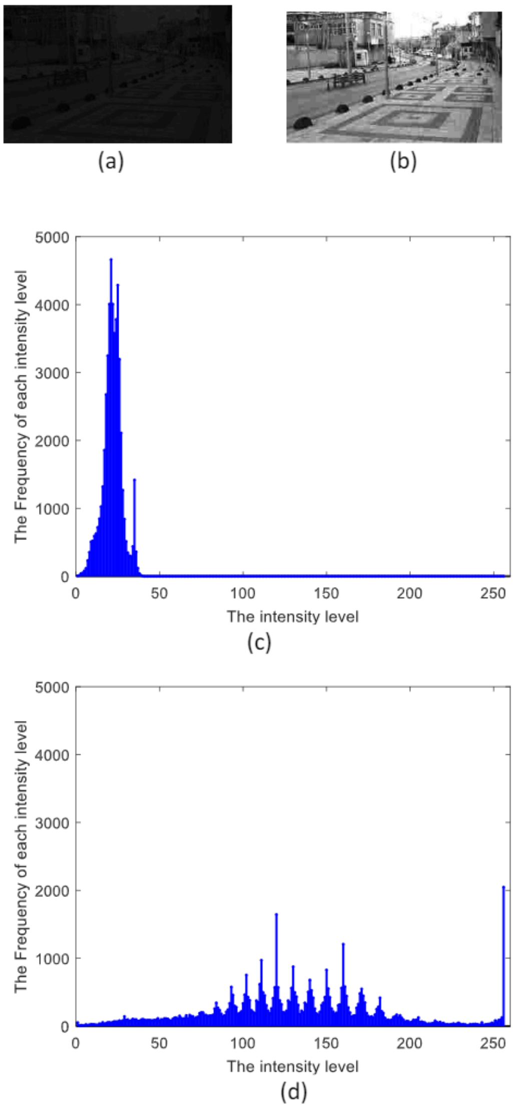

Figure 6. (a)) An image with a very dark level average (b) image obtained by applying the OGVA method to this image (c) The histogram of the image in "a" before applying OGVA (d) The histogram of the image in "b" after applying OGVA.

Comparing the CPU time performances of the proposed OGVA method for different image resolutions, with the CPU time performances evaluated by (Saxena Set all 2016) using brightening image transformation, the results in figure 7 are evaluated for the images with resolutions 256x 256 (65536 pixels), 512 x 512 (262144 pixels), 1024 x 1024 (1048576 pixels), 1800 x 1400 (2520000 pixels) and 4000 x 4000 ($16x10^6$pixels)

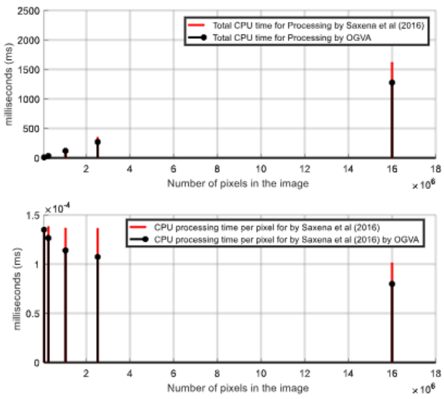

Figure 7. CPU time performance of OGVA with respect to brightening transformation method used by (Saxena S. et. all 2016)

Note that the evaluated results are normalized such that they have the same CPU time values for the image with the resolution 256 x 256. By this way, both the positive or negative effects of used computer hardware while evaluating the resultant images are eliminated, and the results are observed under fair conditions.

According to the results evaluated in figure 7, it is seen that, although the total CPU time for both algorithms increase by an increased resolution of the image, the proposed OGVA method provides less amount of required time per pixel by increased image resolutions.

Table 1 shows the evaluated results and provided improvement rates up to 20.73 % by OGVA using different image resolutions.

Table 1. The evaluated results and provided improvement rates by OGVA using different image resolutions.

Image Resolutions	Number of Pixels	Normalized CPU Time elapsed (ms) using OGVA	Total CPU time per pixel elapsed (ms) using OGVA	Total CPU Time elapsed (ms) in Saxena S. et all 2016)	Total CPU time per pixel elapsed (ms) (Saxena Set al 2016)	Reduced time per pixel by OGVA (%)
256 x 256	65536	8,847	**0,000134995**	8,847	**0,000134995**	0,00
512 x 512	262144	33,17625	**0,000126557**	36,122	**0,000137794**	**8,16**
1024x1024	1048576	119,4345	**0,000113902**	142,678	**0,000136068**	**16,29**
1800x1400	2520000	270,57075	**0,000107369**	342,427	**0,000135884**	**20,98**
4000x4000	$16x10^6$	1276,917	**7,98073E-05**	1610,85	**0,000100678**	**20,73**

5.Conclusion

In this work, a novel method called Optimal Gamma Value Assessment (OGVA) is proposed. By this method, the dynamic intensity adjustment of real-time images became possible in different areas. The optimum gamma value obtained by OGVA method will give an opportunity of having fast dynamic intensity adjustment, and faster histogram equalization effect on the image without delay requiring pixel by pixel high processing power or frequency domain transforms and filtering operations. It has been observed that this method brings the average light level to $2^n / 2$ value of either the dark or the bright images, however it can leave the images with sufficient intensity level unchanged even though the OGVA is applied.

In addition, since this method can be calculated rapidly without high processing load and delay, it can be applied also in the real time systems such as security cameras.

It is shown that, the proposed OGVA method increased the processing time performance especially for higher resolutions by decreased required time per pixel. The results show that up to 20.73 % processing time decrease is provided per pixel for 4000 x 4000 image by use of the proposed OGVA method.

From the results obtained, it can be concluded that the proposed OGVA method achieves optimized results with less processing power causing less delay, as well as the recent studies (Hao S. et. al 2020), (Sajeevu S. et. al 2020) and (Wu Y. 2019) in the literature which succeeded in adjusting the intensity level of the image even under different intensity levels.

In subsequent studies, an algorithm might be studied which will be able to perform an alternative short way to detect specific objects even in dark images without process load and delay.

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