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Efficient Color Image Enhancement Using HSV Color Space and Sub Segment Histogram Equalization

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ABSTRACT

As seen, the image visibility may be poor due to sudden illumination change and cast of shadows due to nearby object. Due to that, it requires the image enhancement which has been an extensively used process for the better visual perception of the image. Amongst many methods of image enhancement, the histogram equalization is the most commonly used method due to its ease. However, the global histogram equalization method enhances the region in image where sometimes it does not require the manipulation. In order to handle this situation, local histogram method is proposed that preserve the color component and improve the visibility in the highly contrast reason. In this work, we utilized V-transform technique to sub-divide the region into sub-segment and the local contrast is improved without disturbing the color component of the image. A weighted value is determined to estimate the correct pixels at certain location for the better visibility. Experimental results on some standard datasets show that the proposed method enhances the degraded image effectively without deteriorating the color component of the images.

Keywords: V transform, HSV, Histogram equalization.

1. INTRODUCTION

It is observed that the image enhancement is a crucial pre-processing step for many computer vision systems. Sometime, the acquisition devices fail to adapt the high dynamics changes in the scene. So many image enhancement processes has been proposed in the literature that apply on different sets of criteria. As seen, the scene or image may be affected due to many reason such as change in illumination, shadows cast by neighbour object, fail in range handling capacity of device, noise during acquisition, transmission and reception. The above factors may affect and change the actual colour, brightness, contrast. Therefore, the multiscale image enhancement has become the great area of research in computer vision. The challenges before one has to preserve the color, edges, tonal and proper contrast of the images. However, a direct multi-scale image enhancement algorithm capable of independently and/or simultaneously providing adequate contrast enhancement, tonal rendition, dynamic range compression, and accurate edge preservation in a controlled manner has yet to be produced[19].

The improvement in contrast effectively recovers the visual quality that helps to understand the image content and distinguish the object in the region of interest from the background. The simplicity and quickness make the histogram equalization technique as most extensively used tool for image enhancement. Further to improve the local region of the image, the sub-image enhancement technique is proposed in the previous work. A non-linear diffusion equation is proposed to reduce the sudden illumination change in[1]. The diffusion strength in textural image is estimated and the neighbour's suppression is done for the degraded images. In this work, we have proposed the image enhancement techniques that utilize the contrast enhancement in the degraded region and preserve the colour of the input image. The other section of the paper is organized as follows. In Section II, literature review is done of some widely used effective image enhancement techniques. Proposed method is explained in Section III. The .Experimental results on some standard dataset are presented in Section Iv. The paper is concluded in V.

2. LITERATURE REVIEW

In[1], authors used a non-linear diffusion equation is utilized to improve the diffusive strength in the textural areas of an image. It achieved two benefits that the method is capable to preserve the boundary of the image due to the sudden illumination and also the halo artefact is eliminated. The second strength of the algorithm is to preserve the texture details of the images under the illumination condition. Since the illumination suppression requires the suppression of the pixels in images that may change the contrast and destroy the original information of the scene.

In[2], authors proposed optimization-based framework that employ the convolution term, a fidelity and a prior term that regularizes the pixel value and obtained the image that is resembled with the original one. It utilizes the approximation of the median filtering process with the generalized Gaussian as the distribution model and estimated the pixels of the original one.

The GMM framework is used in this method that accumulates the similar patches using the multivariate Gaussian probability. It improves the local contrast greatly and preserves the tonal value of the images. The idea is patch based clustering approach that provides better goodness-of-fit to statistical properties of natural images[3].

Authors proposed used to preserve the backlight-scaled images as much as possible. It utilizes the luminance and chrominance components which account into an integral manner[4].

In this method the entropy maximization process is used for the tone preserving. It constructed the K-edges maximum-weight path that optimizes the correct brightness and estimated the correct pixels at the spot[5].

In[6], authors used the weighted transform functions has been used to enhance the contrast of the image. The mean value is used to calculate the similarity and dissimilarity that further calculated the weighted transformation functions. The bin of the histogram is filtered out to increase the dynamic range of the enhanced image.

In[7], the author proposed a real time filtering is proposed to enhance the finger print image. It split a modified anisotropic Gaussian filter into two orthogonal Gaussians and an oriented line Gaussian which in turns developed the architecture to adjust the dynamics of the scene.

In[8], authors used the output image of low resolution camera and the high resolution RGN camera for exploiting the statistical correlation. It used the guided weight function for the dependency modelling that updated the depth of the image with a optimal restoration.

In[9], the authors proposed the histogram modification framework to enhance the colour and depth of the images. It partitioned the image into subinterval using the Gaussian mixture model. The spatially similar pixels having the same intensity level is grouped together. A mapping is proposed to enhance the depth and contrast of the image without over enhancing the contrast of the image.

In[10]. The author proposed an adaptive contrast enhancement algorithm by preserving the one dimensional histogram and the histogram obtained by gray level difference between the two neighboring pixels. The one dimensional histogram is utilized in enhancing the contrast of the image, while 2d histogram used to improve the detail of the frequently occurring the non smoothing area in an image.

3. PROPOSED METHODOLOGY

As seen, the limited dynamic ranges of imaging and display device limits the capability of handling the high dynamic range scenes. In the first stage, we have compressed the dynamic range and enhanced the local contrast using[12]. It is focused to keep constant the tonality of image while increasing the luminance in the shadows region. In aid to this, local contrast enhancement method is applied to the above procedure. The above process may improve the quality of image without creating unnatural rendition in it. It utilizes the hyperbolic tangent part of the image that enhances the dark region of the image while preserve the light part region.

$$I_{u,v} = \frac{2}{1+e^{-2\tau_{u.v}/\rho}} - 1 \quad (1)$$

Where $\tau_{u,v}$ is the value that can be computed through the V component pixel in HSV.
'ρ'is the statistical parameters of the image, and $I_{u,v}$ is the normalized enhanced pixel value. The parameter 'ρ' should be kept small to transform the darker region pixels in to the brighter region pixels. While the smaller value of 'ρ' will keep the better colour retention.

$$\rho = (255 - k)\left[\frac{\gamma_{u,v}}{255}\right] + k \quad (2)$$

Where $\gamma_{u,v}$ represents the local mean of an image and the value of k is the value of bias pixel intensity value. Considering the perceptual field and perceptual processes of human vision, the value of 'K' is taken as 3.

$$\gamma_{u,v} = ce^{\frac{-(u^2+v^2)}{\sigma^2}} * \tau_{u,v} \tag{3}$$

The Gaussian probability density function is chosen to calculate the mean of the pixels of the image and the value of sigma is the trade-off between the intensity compression and color retention.

If the shadow is attempted to remove from the image the local intensity contrast will be degraded . Therefore, in order to preserve the local contrast enhancement, the intensity variation is define as follows:

$$I_v = \frac{I_{u,v} - I_{avg}}{255} \tag{4}$$

In the above equation the difference may be either positive or negative. The larger magnitude represents the higher contrast while the lower magnitude will represent the lower contrast. In order to increase the lower contrast, the power law operation is applied as follows;

In the above equation the value of beta is taken as less than one. The enhanced restored image is found using the given equation that increased the local contrast of the image.

$$|I_{V1}| = |I_v|^{\beta} \tag{5}$$

Since the value of the enhance factor may be greater than one , therefore the value can be normalize to one using the given equation.

$$I_n = \frac{I_v + I_{avg}}{max(I_v + I_{avg})} \tag{6}$$

As we know that the HSV represents hue, saturation and value (brightness). The V transform is applied to improve the quality of images by increasing the brightness without changing the colour component[12]. In the colour image, it is applied in the one component that is 'V'. So its computational complexity is low. The steps of the V transform are as follows:

(i) The input RGB image is converted in to The HSV model.
(ii) Extract the V vector from the HSV model.
(iii) Sort the V vector in ascending way.
(iv) Divide the sorted segment in N equal interval segment.
(v) Assign the start and end value to each segment of sorted V vector.

If the input image contains lot of color, the value of N is taken as one while for the higher values of N, the transformed image will contain more contrast and strange effects.

Since the alone v transform do not handle the contrast in local region and the adjusted the brightness globally. However the local contrast and intensity calculation is trade-off between the two parameters. The output image found to be change in color if we adjust the parameter to improve the contrast locally.

In order to improve the contrast by maintaining the brightness in the dark region is proposed in the work. The reconstructed image is well adjusted near the dark region and the contrast is also improved by averaging the global intensity. The flow diagram of the proposed method is shown in figure 1.

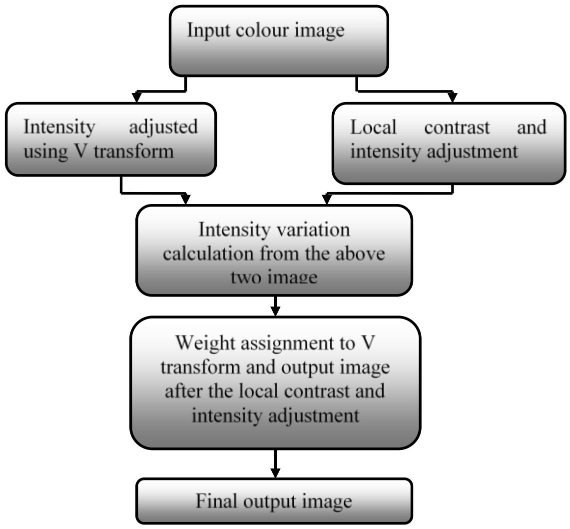

Figure. 1 flow diagram of the proposed method

Consider an image 'X' in which , the V transformed is applied to adjust the intensity at dark region but globally. The same image is sent through the procedure[11], through which the brightness and contrast is adjusted. Consider the output image through V transform is X_V and the output through[12] is X_L. A variation factor in intensity is calculated between the two images is given as follows:

$$P = \frac{X_V - X_L}{X_V + X_L} \tag{7}$$

The reconstructed image 'R' is calculated as:

$$R=P^* X_V+(1-P)^* X_L \tag{8}$$

The work is also extended to enhance the edges of the output image. All the channel of the reconstructed image is passed through the average filter. The edge is sharpened using the following equation as follows:

R1(Edge sharpened image)=R-(λ*filtered image)/β (9)

Where, λ and β are the empirically defined parameter.

4. EXPERIMENTAL RESULTS

In the section, some standard dataset has been taken to verify the applicability of the proposed method in the experimental analysis.

Figure 2. Restored image by different methods (a) Original Image (b) Histogram equalization method(c) Method (d) V-transform method (e) Proposed method. (f)(Proposed method with sharp filter.

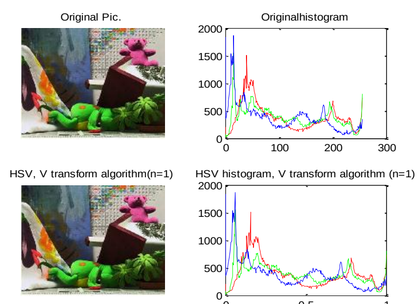

Fig 3. Histogram equalization using V transform

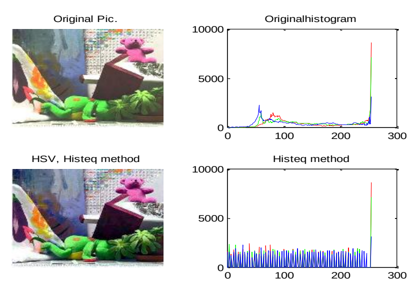

Fig 4. Histogram equalization method

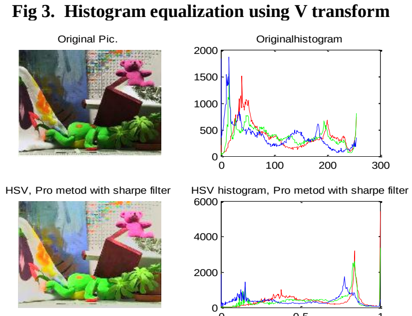

Fig 5. Histogram equalization using V transform

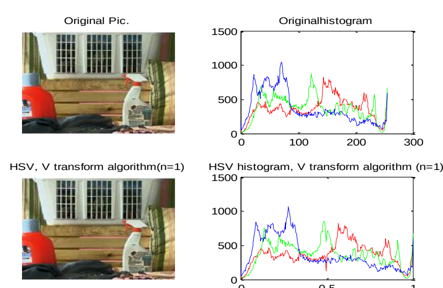

Fig 6. Histogram equalization using V transform

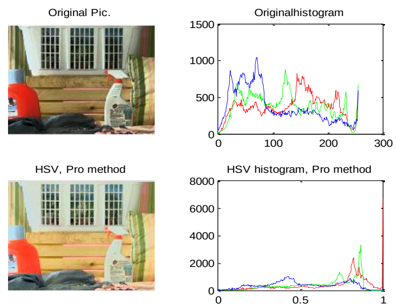

Fig7. Histogram equalization using Proposed method

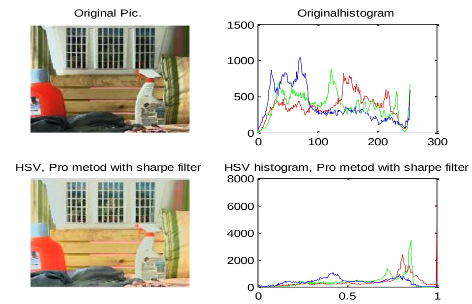

Fig 8. Histogram equalization using proposed method with sharp filter.

In order evaluate the visual quality of the image; we have applied this proposed method into some standard dataset. In Figure 2 first row shows the original input image. It can be shown that some image the quality is degraded locally and some images, the images contrast is affected locally. The Door and sunset images are affected globally due to low visibility. The image that contain teddy is affected locally due to shadow near by the object. It can be observed that the proposed method effectively enhanced the image at global and local level. Figure 3 and 4 show the histogram of the input image and the image enhancement through histogram equalization. It can be seen that the pixel distribution is done on the entire range of image and the dark pixels is shifted toward the appropriate pixels intensity. Figure 5 shows the image enhancement through the proposed method that successfully eliminated the local darkness near the curtain and leaves. Figure 6,7 & 8 shows the enhancement on the wood image. It is seen that the visibility is clear on the wood and curtain at the corner of the room attains the pretty well visibility.

Along with qualitative analysis, the quantitative parameter is also evaluated to examine the efficiency of the propose method. A quantitative parameter color root mean enhancement measure (CRME) is calculated to indicate the color image contrast quality. Higher the value of color root mean enhancement measure, better would be the image quality[13-17].

Table 1 CMRE of the input image

Object	Proposed method
Teddy	0.3058
Wood	0.2631
Door	0.2122
Sunset	0.3118
Peppers	0.2013

Table 2 Comparison of average CMRE between other methods and propose one on the images available in datasets

Method	Histogram equalization	Method[18]	Method[10]	Proposed method
Average Quality relative contrast measure	0.1412	0.1324	0.2197	0.2666

In table 1, it can be observed that the individual CMRE is achieved better through the proposed method. This suggests that the proposed method produces image which contains good contrast quality and better tonal retention. In table, it can be observed that the average CMRE achieved through the proposed method has achieved good contrast quality than others.

5. CONCLUSION

In this work, we have proposed the efficient image enhancement technique that enhances the contrast of image while keeping the brightness level optimum at local and global level. We utilized the V-transform method and local contrast adjustment method to achieve the optimum intensity level at the output. A weight is calculated and provides to V-transform image and locally improved contrast image to optimize the correct pixels at the reconstructed image. Experimental results show that the proposed method achieves the better contrast improvement ration than other existing state-of-the-art image enhancement methods.

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