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Color Image Analysis and Contrast Stretching using Histogram Equalization

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***Abstract*—A process of improve quality of a digitally stored image by manipulating the image with various techniques. The various papers on histogram equalization describe only on a gray scale image. In this paper, however it can also be used on color images by applying the same method separately to the Red, Green and Blue components of the RGB color intensity values of the image. Image enhancement is used to improve the quality of poor images.**

The aim of this paper is to improve the quality of an color image for human viewers, or to provide `better' input for other automated image processing techniques. It proposes a scheme for image contrast enhancement based on a generalization of histogram equalization (HE). HE is a useful technique for improving image contrast, but its effect is too severe for many purposes. It is one of the well known image enhancement technique.

It became a popular technique for contrast enhancement because this method is simple and effective. Comparative analysis of different enhancement techniques will be carried out. This comparison will be done on the basis of subjective and objective parameters. Subjective parameters are visual quality and computation time and objective parameter histogram error can be measured. We are discussing three methods of image enhancement: 1. Histogram Processing, 2. Histogram Equalization, and 3. Contrast enhancement by histogram stretching.

Index terms* –*Histogram Equalization (HE), Histogram processing (HP), Histogram Error, Histogram Stretching.

I. INTRODUCTION

A. Color Image Analysis

An Image Histogram is a type of histogram that acts as a graphical representation of the lightness/color distribution in a digital image. It plots the number of pixels for each value. Image Enhancement is one of the important requirements in Digital Image Processing which is vital in making an image useful for various applications which can be seen in the areas of Digital photography, Medicine, Geographic Information System, Industrial Inspection, Law Enforcement and many more Digital Image Applications[1].

A visual image is rich in information. Confucius said, "A picture is worth a thousand words." [2] Image Enhancement is simple and most appealing area among all the digital image processing techniques. Process of manipulating an image so that the result is more suitable than the original for specific applications. The idea behind enhancement techniques is to bring out details that are hidden, or simple to highlight certain features of interest in an image. Improving the appearance of an image tend to be mathematical or probabilistic models. Enhancement, on the other hand, is based on human subjective preferences regarding what constitutes a "good" enhancement result. Use the colour of the image to extract features of interest in an image.

B. Histogram Processing

Digital image analysis one of the most important technologies which are necessary to improve the visual appearance of the image or to provide a better transform representation for future automated image processing such as pre-processing, detection, segmentation and recognition. Many images have very low dynamic range of the intensity values due to insufficient illumination and therefore need to be processed before being displayed.

Large numbers of techniques have focused on the enhancement of gray level images in the spatial domain. Y.-T. Kim [3] developed a method for contrast enhancement using brightness preserving bi-histogram equalization. Similar method for image contrast enhancement is developed by Y. W. Qian [4]. Image Enhancement basically includes noise reduction from the image [7]. A histogram is the estimation of the probability distribution of a particular type of data. An image histogram is a type of histogram which offers a graphical representation of the tonal distribution of the gray values in a digital image. By viewing the image's histogram, we can analyze the frequency of appearance of the different gray levels contained in the image [5]. The figure below shows an image with its histogram representation. The pixels in the image have a wide histogram representation indicating that the image is of a high quality.

The histogram of a digital image with intensity levels in the range [0, L – 1] is a discrete function $h(r_k) = n_k$, where r_k is the k^{th} intensity value and n_k is the number of pixels in the image with intensity of r_k [1]. It is common practice to normalize a histogram by dividing each of its components by the total number of pixels in the image, denoted by the product MN, where, as usual, M and N are the row and column dimensions of the image. Thus, a normalized histogram is given by $p(r_k) = n_k / MN$, for K = 0,1,2,……, L – 1. Loosely speaking, $p(r_k)$ is an estimate of the probability of occurrence of intensity level r_k in an image [6]. The sum of all components of a normalized histogram is equal to 1. The histogram of bad images is usually narrow while that of good images are wide. To change a bad image to a good one, the histogram is thus modified. The figure below shows an example of a histogram representing a bad and a good image [6]. It is a graph of the frequency of occurrence of each RGB level in an image, histogram of an image is a one dimensional discrete function, which can be represented as follows:

$$\mathbf{h = n_k} \quad \text{------- (1)}$$

in which nk is the number of pixels with the gray value of k in image F(i, j) . Consequently, the probability density function (PDF) can be obtained according to equation (1).

$$\mathbf{P_s(S_k) = \frac{n_k}{n}\ \ 0 \le S_k \le 1, k\ 1, 2.., n-1} \qquad \text{------ (2)}$$

Where sk (k= 0,1,2... n-1) denotes the k th gray-level of F(i, j) and n is the total number of pixels in the image. Therefore, the cumulative distribution function (CDF) can be obtained by utilizing the gray-scale transform.

$$\mathbf{t_k = E_h\ (S_k\ ) = \sum_{i=0}^{k} ni/n\ \sum_{i=0}^{k} p_s(s_{i)}\ )} \qquad \text{------ (3)}$$

The Pixels with the intensity of S_k in the input image are mapped to the corresponding pixels with the intensity of t_k in output image according equation (3). Theoretically the color channels or the probability density function of an image will produce a perfectly equalized histogram through such a mapping mechanism.

However the color channels and the probability density function may not be exactly uniform in practical applications because of the discrete nature of the pixel intensities. As a result, pixels with a high probability of RGB level may be over enhanced and pixels with a lower probability of RGB be lack of enhancement or even be removed. Therefore, HE always enhances the background of an image excessively and decreases the saturation of the small area with most interesting. The histogram processing can be demonstrated on an color image of a sun. An input color image and its histogram are shown in Figure 1; their respective histograms are shown in Figure 2.

Figure1: Sun image

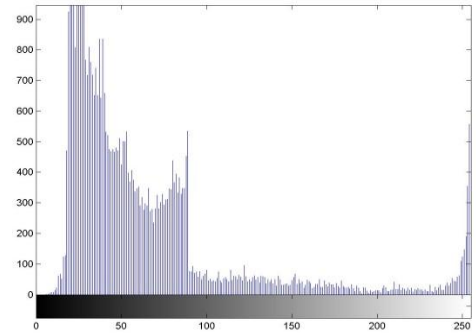


Figure 2: Histogram of Sun image

II. Related Work

S. Mukhopadhyay B. Chanda [1] have proposed allows a multi-scale scheme for contrast enhancement of color images. The magnitude image constructed from the red, green and blue color is enhanced using multi-scale morphological filters keeping the direction of the color vector unaltered. The enhanced color image is obtained by combining the enhanced magnitude image with the original direction cosine values. But, it lacks the method to satisfy this request naturally. Eigen Trust is just a representative and most existing trust evaluation systems have the same requirement, but omit uncertainty the same time.

Fari Muhammad Abubakar [1] have concentrated on image enhancement using histogram equalization specially on spatial domain.

S. Lau [2] have proposed work on global image enhancement using local information histogram is divided into clusters and histogram equalization or stretching is performed on each cluster thereby producing a modified histogram. Using said modified histogram to adjust the value of said first measurable property in said digital form, thereby producing a contrast enhanced image.

Y.-T. Kim [3] have enhanced the bi histogram equalization for preserving brightness of an image, HE methods for gray-level images are concerned, current methods tend to change the mean brightness of the image to the middle level of the gray-level range. This is not desirable in the case of image contrast enhancement for consumer electronics products, where preserving the input brightness of the image is required to avoid the generation of non-existing artifacts in the output image. To overcome this drawback, Bi-histogram equalization methods for both preserving the brightness and contrast enhancement have been proposed.

Yu Wang, Q. Chen, and B. Zhang [4] suggested that Image enhancement based on equal area dualistic sub-image histogram equalization method concluded that dualistic property on sub image histogram.

Ji-Hee Han, Sejung Yang, Byung-Uk Lee, The majority of color histogram equalization methods do not yield uniform histogram in gray scale. After converting a color histogram equalized image into gray scale, the contrast of the converted image is worse than that of an 1-D gray scale histogram equalized image.

III. Objectives & Overview Of The Proposed Method

A. *Objectives*

In this paper, we propose to Histogram equalization [9] is a common technique for enhancing the appearance of images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram. It is a contrast enhancement technique with the objective to obtain a new enhanced image with a uniform histogram [11].

Equalization involves intensity values of the image, not the color components. So for a simple RGB color image, histogram equalization cannot be applied directly on the channels. It needs to be applied in such a way that the intensity values are equalized without disturbing the color balance of the image. So, the first step is to convert the color space of the image from RGB into one of the color spaces that separates intensity values from color components.

HE techniques are widely used in our daily life, such that in the field of consumer electronics, medical image processing, image matching and searching, speech recognition and texture synthesis because it has high efficiency and simplicity [8],[9],[10],[11]. The main idea of HE-based methods is to re-assign the intensity values of pixels to make the intensity distribution uniform to utmost extent. To enhance an image, a brightness preserving Bi-HE (BBHE) method was proposed in [3]. The BBHE method decomposes the original image into two sub-images, by using the image mean gray level, and then applies the HE method on each of the sub images independently. At some extent BBHE preserves brightness of image.

- Transformation form: $s = T(r),\ 0 \le r \le 1$
- Inverse Form: $r = T^{-1}(s),\ 0 \le s \le 1$

As shown in the above equations, consider an image whose pixel values are confined to some specific range of values only. For example, brighter image will have all pixels confined to high values. But a good image will have pixels from all regions of the image. So you need to stretch this histogram to either ends.

B. *Overview of the proposed method*

We propose a Color image analysis using histogram equalization. It uses RGB color channels are showed in the form of graphical representation such as histogram. Each channel of color image having different intensity values based on that we are performing histogram equalization as shown in the fallowing figures.

Histogram equalization of a color image can be performed by adjusting color intensity uniformly while leaving color unchanged. The HSI model is suitable for histogram equalization where only Intensity (I) component is equalized. Where ‘r’ and ‘s’ are intensity components of input and output color image.

$$S_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j)$$

$$= \sum_{j=0}^{k} n_j / N$$

The histogram equalization can be demonstrated on an color image of a sun. An input color image and its histogram equalization are shown in Figure 3; their respective equalized histograms are shown in Figure 4.

Figure 3: Equalized Sun Image

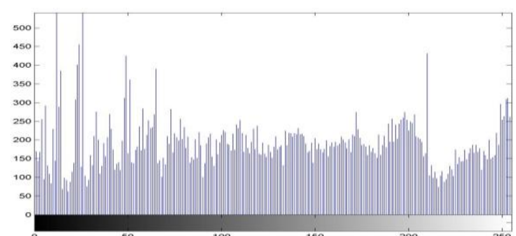


Figure 4: Equalized image histogram

IV. Histogram Stretching for contrasting

A. *Histogram Stretching*

In our proposed system, by dynamically calculating the histogram error on original color image and equalized color image, then we can observe the intensity values of the RGB color channels; Histogram stretching involves modifying the brightness (intensity) values of pixels in the image according to a mapping function that specifies an output pixel brightness value for each input pixel brightness value (see Figure 5).

For a gray scale digital image, this process is straightforward. For an RGB color space digital image, histogram stretching can be accomplished by converting the image to a hue, saturation, intensity (HSI) color space representation of the image and applying the brightness mapping operation to the intensity information alone. The following mapping function is often utilized to compute pixel brightness values:

$$Output(x, y) = (Input(x, y) - B) / (W - B)$$

In the above equation, the intensity range is assumed to lie between 0.0 and 1.0, with 0.0 representing black and 1.0 representing white. The variable B represents the intensity value corresponding to the black level, while the intensity value corresponding to the white level is represented by the variable W.

In some instances, it is desirable to apply a nonlinear mapping function to a digital image in order to selectively modify portions of the image.

Figure 5: Nature Imag

Figure 6:Histogram Stretched Image

V. PERFORMANCE EVALUATION

A. Performance Metrics

We evaluate mainly the performance using histogram error as shown in the fallowing. The Histogram Error is another metrics used to compare image quality. It will take sum of intensity of original image and sum of intensity of equalized image we get histogram error.

$$\boldsymbol{f} = \sum_{\boldsymbol{n}=1}^{256} \left(\boldsymbol{h1}(\boldsymbol{n}) + \boldsymbol{h2}(\boldsymbol{n})\right)^{2}$$

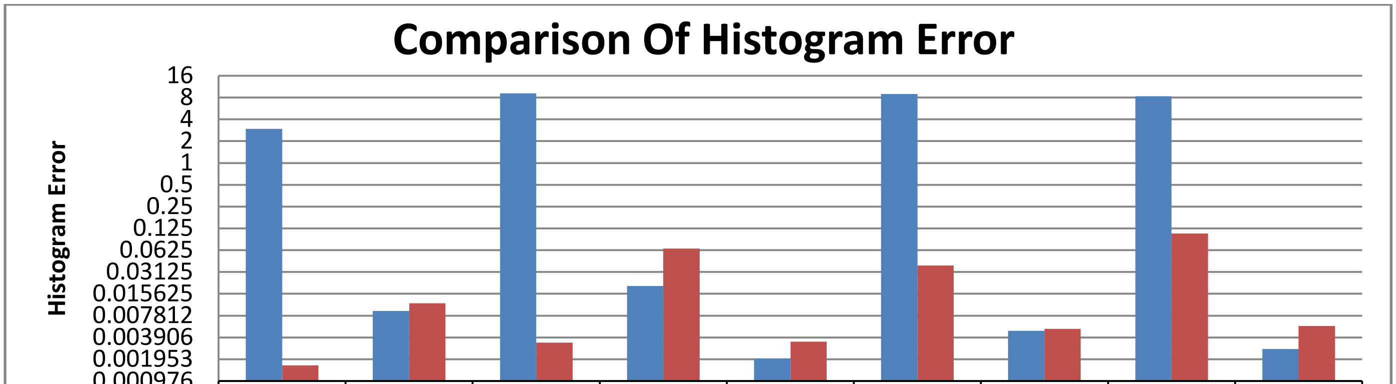
The conditions of Histogram Error are.

- If error is less than zero then little difference in two images.
- If error is zero there is no difference in two images.
- If error is greater than zero then more difference in two images

B. Results

The comparison of histogram of color image with equalized color image and histogram stretching of color image can be measured by histogram error as shown in the above equation. The fallowing illustrates the comparison bar chart of histogram error; we can observe which method having highest brightness and clearer image compared to other methods. In this we showed that which method having histogram error less than 0 is little difference in two images as we mentioned conditions in histogram error measure.

The figure 9 and figure 10 illustrates the original color image, stretched color image and equalized color image differences in the form of Histogram error and graphical representation of histogram in color.. The bar chart shows the comparison between original color image histogram with stretched color image histogram of color image histogram with Equalized.



	Img1	Img2	Img3	Img4	Img5	Img6	Img7	Img8	Img9
Str_Hist_Err	2.9427	0.0091	9.1079	0.0201	0.002	8.9726	0.0048	8.383	0.0027
Eq_Hist_Err	0.0016	0.0116	0.0033	0.0656	0.0034	0.0384	0.0051	0.1065	0.0056

Figure 9: Histogram comparison Result

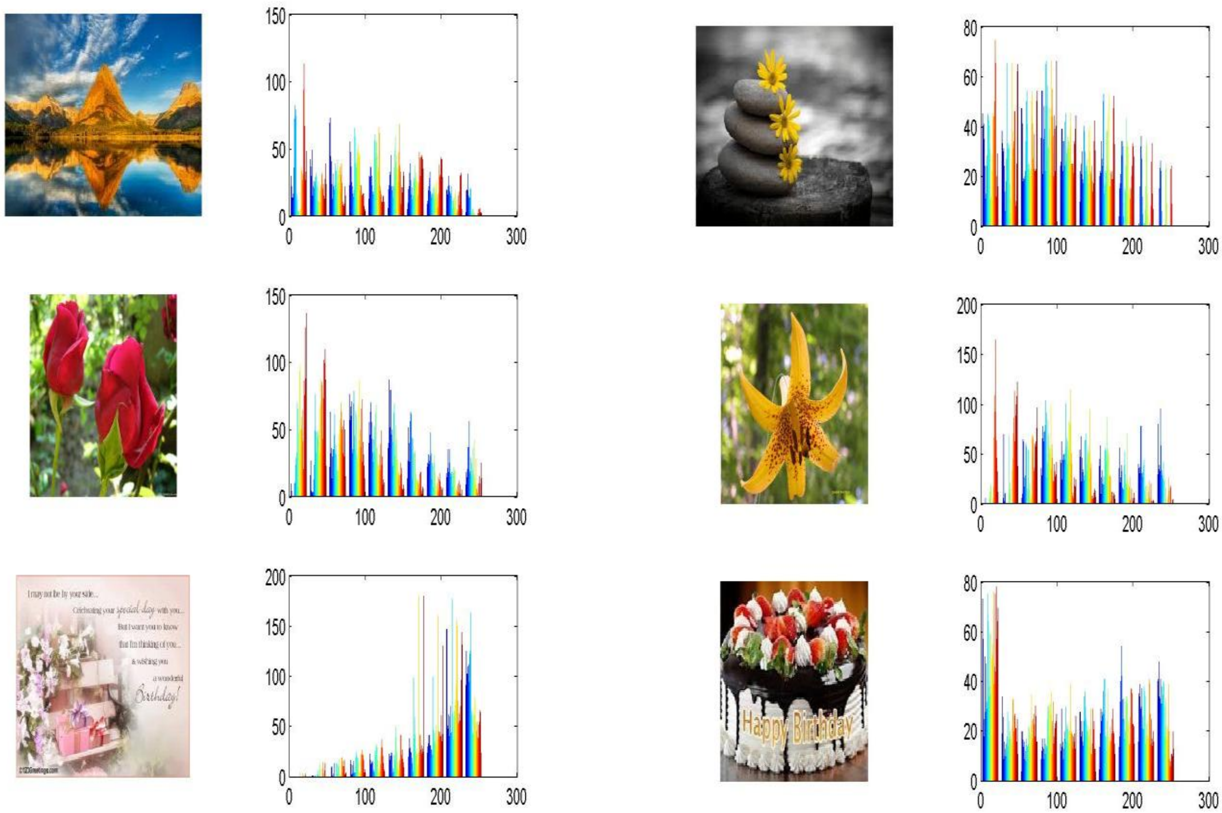


Figure 10: Color Histogram of image

VI. CONCLUSION

In this proposed work in this paper we shown the histogram in color image can be done such as RGB components. From the literature survey observed that various papers histogram equalization is done only on gray images. Histogram Error is then calculated to measure the performance of enhanced image. It is observed from the experimented results that the equalized color image having better contrast then the original image it not only enhances the visual quality of the image but also preserves the brightness level.

The method has been implemented on nine different images to check experimental results. Image analysis is one of the most important processing technologies which are necessary to improve the visual appearance of the image or to provide a better transform representation for future automated image processing.

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Authors Profile

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