Far East Journal of Electronics and Communications
100 *Proceedings of SHANNON* - 3rd *Int. Conf. Comp. Sci.*, 2016

http://dx.doi.org/10.17654/ECSV3PI16057
Special Volume 3, Part I, 2016, Pages 57-70 **ISSN: 0973-7006**

HYPER GEOMETRICALLY MODIFIED ABSOLUTE MEAN BI-HISTOGRAM EQUALIZATION ON GRAY SCALE SEGMENTED IMAGES TO IMPROVE CONTRAST

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Abstract

An amalgamation of a new technique and an old technique is presented in this paper for the purpose of better enhancement of contrast and brightness preservation of low contrast grayscale segmented images. The proposed technique is named as Hyper Geometrically Modified Absolute Mean Bi-Histogram Equalization (HGAMBHE). The basic idea of the proposed method is to segment the histogram of the image based on Hyper Geometric cumulative distribution function (CDF). Then the segmented histogram of the image is divided into two parts based on an average point with respect to Hyper Geometric CDF. A standard value of above applied distributive function is taken for the calculation of absolute modified

Conference held during April 8-9, 2016 at Lovely Professional University, Punjab, India.
Guest Editor: G. Geetha; Division of Research and Development, Lovely Professional University, Punjab, India.
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mean (AMM) and peak signal to noise ratio (PSNR). Based on absolute modified mean value of the histogram, calculations of different parameters to determine the brightness preservation and contrast enhancement are done. This proposed method is found to provide more accurate and realistic results.

1. Introduction

The main objective of enhancement is to process an image so that the processed image can have finer details than that of the original image for certain specific applications. Contrast enhancement method, a wider dynamic range in image processing, is widely in use. Histogram equalization is a well-known contrast enhancement technique due to its performance on almost all types of image. Generally, histogram equalization can be categorized into two main processes, viz., global histogram equalization (GHE) and local histogram equalization (LHE) [1]. The computational complexity of GHE is comparatively low, making GHE an attractive technique in many contrast-enhancement applications. The major drawbacks of global histogram equalization (GHE) are that it cannot adapt the local information of the image and preserve the brightness of the original input image. In contrast, local histogram equalization (LHE) uses a sliding window method, in which local histograms are computed from the windowed neighborhood to produce local intensities by remapping each pixel in the chosen window. The intensity of the pixel at the center of the neighborhood pixel is changed according to the local intensity remapping for that pixel [7]. There are different methods of histogram equalization in image enhancement techniques [4]. Histogram equalization is used to equalize and often used in different field by processing satellite images or X-ray images (Medical Imaging). Histogram equalization also produces gradient images with respect to the low color depth. The graphical representation includes gray level and number of pixels. If the color depth of an image is very high, then histogram equalization provides best output result. That means that more number of data images are of the high color depth images [1, 9].

Proposed method is based on Hyper Geometrical Modification (HGAMBHE) which is found to provide more advantages compared to other existing histogram equalization techniques. In the present paper, histogram [8] of test images is segmented in different parts with respect to the gray level and Hyper Geometric CDF. Then the average values of each gray level are considered to calculate the absolute modified mean value and other parameters to get the output processed image. The proposed technique is found to provide more accurate result and preserve the brightness as well as contrast compared to other existing histogram equalisation techniques [11].

2. Related Research Work

There are different histogram equalization techniques. Among them histogram equalization and bi-histogram equalization are related to work [2].

2.1. Histogram equalization

Histogram equalization process is used to equalize the histogram of an image, i.e., equalize the color depth. These methods seek to adjust the image to make it easier to analyze or improve visual quality [6].

Let $X = \{X(i, j)\}$ an image composed of L discrete gray levels denotes as,

$$X = \{X_0, X_1, ..., X_{L-1}\}. \quad (1)$$

If the image is given by the set X, the function of probability density is

$$p(X_Z) = \frac{n^Z}{n}, \quad (2)$$

where, $Z = 0, 1, ..., L-1$, n^Z, the number of times at the level X_Z.

Hence, A is the input image X, n is the total number of samples in the input image, $p(X_Z)$ is associated with specific intensity (X_Z) by representing the number of pixel with respect to the histogram.

The CFD (Cumulative Density Function) is defined based on PDF is as given below:

$$c(x) = \sum_{j=0}^{z} p(X_j), \tag{3}$$

where, $Z = 0, 1, \ldots, L-1$.

HE is a scheme that maps the input image into the entire dynamic range (X_0, X_{L-1}) described by using the cumulative density function (CDF). A transformation function $f(x)$ is based on the CDF defined as,

$$f(x) = X_0 + (X_{L-1} - X_0)c(x). \tag{4}$$

Then the output image of the HE, $Y = \{Y(i, j)\}$ can be expressed as,

$$\gamma = f(x) f\left\{\frac{X(i, j)}{\forall X(i, f)} \in X\right\}. \tag{5}$$

2.2. Bi-histogram equalization

The histogram of the original image is separated into two sub-histograms based on the mean value of the histogram of original image; the sub-histograms are equalized independently using refined histogram equalization (HE), which produces flatter histogram [5].

Let I_m denote the mean of the input image f and assume that $I_m \in [0, -1]$.

Depending on I_m, the image separated into two sub-images f_i and f_j as,

$$f = f_i \cup f_j f_i = \{f(x, y) | f(x, y) \le I_{m, \forall f(x, y) \in f}\} f_i$$

$$= \{f(x, y) | f(x, y) > I_{m, \forall f(x, y) \in f}\}.$$

The probability density function of sub-images f_i and f_j is defined as [10],

$$p_i(I_k) = \frac{n_i^k}{n_i} \; p_j(I_k) = \frac{n_j^k}{n_j}.$$

The respective CDF’s are defined as,

$$P_i(I_k) = \sum_{k=0}^{I_m} p_i(I_k),$$

$$P_j(I_k) = \sum_{k=I_{m+1}}^{I_{m-1}} p_j(I_k), \tag{6}$$

where $P_i(I_k) = 1$ and $P_j(I_k) = 1$ by definition.

The transformation functions exploiting the CDFs,

$$T_i(I_k) = I_0 + (I_m - I_0)P_i(I_k)T_j(I_k)$$
$$= I_{m+1} + (I_{L+1} - I_{m-1})P_j(I_k). \tag{7}$$

Then the output image of the histogram can be expressed as,

$$g(x, y) = T(f(x, y)). \tag{8}$$

3. Proposed Method

Based on the previously studied methods, a new approach has been made to the process of histogram equalization. The new and better method of Histogram equalization is Hyper-Geometrically Absolute Mean Bi-Histogram Equalization (HGAMBHE). Basically an image is taken into consideration. This image is then taken into account for the process of segmentation. After segmentation, the parameters mean, skewness, modified mean, absolute mean and the PSNR values are calculated. These parameters are calculated because as we get the mean and skewness values it can be calculated. The modified and absolute mean values which should be less and the PSNR should be high. Higher PSNR mean less noise in the image and hence clarity increases and lower absolute mean indicates much of the number of pixels and hence information is retained even after segmentation. This HGAMBHE produces the desired results, better than the previously mentioned methods and are shown later. While proposing the above method, the parameters [3] taken into consideration are defined below with their corresponding expressions.

3.1. Mean

The arithmetic mean of a sample $x_1, x_2, ..., x_n$ usually denoted by $\bar{x}$, is the sum of the sampled values divided by number of items in the sample:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n}. \tag{9}$$

3.2. Skewness

In probability theory and statistics, skewness is a measure of asymmetry of the PDF of a real-valued random variable about its mean. The value of the skewness can be positive or negative, or even undefined. It is expressed as,

$$\gamma_1 = E\left[\left(\frac{X - \mu}{\sigma}\right)^3\right] = \frac{\mu_3}{\sigma^3} = \frac{E[(X - \mu)^3)}{(E[(X - \mu)^2])^{3/2}} = \frac{K_3}{K_2^{3/2}}. \tag{10}$$

3.3. Modified mean

The parameter modified mean of an image can be calculated knowing the mean and skewness values. The modified mean can be expressed as,

$$\gamma = \sqrt{\bar{x} - n}. \tag{11}$$

3.4. Absolute modified means

The mean absolute value (MAV) is calculated using a moving window. The MAV is calculated for each window of data according to the equation:

$$MAV = \frac{1}{S}\sum_{1}^{s} | f(s) |, \tag{12}$$

where, MAV-Mean Absolute Value, *S*-Window Length (Points) and $f(s)$-Data within the Window.

3.5. PSNR

PSNR is defined via the mean squared error (*MSE*). Given a noise-free

$m \times n$ monochrome image *I* and the noisy approximation of that image is *K*, *MSE* is defined as:

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(x, y) - K(i, j)]^2. \quad (13)$$

4. Experimental Results and Discussions

The performance of proposed method Hyper Geometrically Modified Absolute Mean Bi-Histogram Equalization (HGAMBHE) is observed with the test image shown in Figure 1. Figure 2 is shown for gray segmented image which is determined by Hyper Geometric CDF and Average mean value. After that the absolute mean value is applied on segmented image to reform the image function of hyper geometric CDF. This is the result of HGAMBHE shown in Figure 3 below.

Figure 1. Input Image.

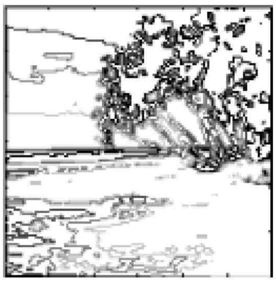

Figure 2. Gray Segmented Image.

Figure 3. HGAMBHE output.

Now low contrast input test_2 image in Figure 4 is considered to determine the quality of HGAMBHE technique.

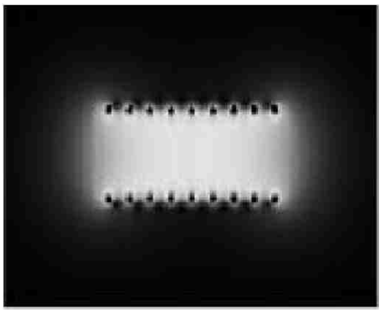

Figure 4. Input test_2 image (Low Contrast).

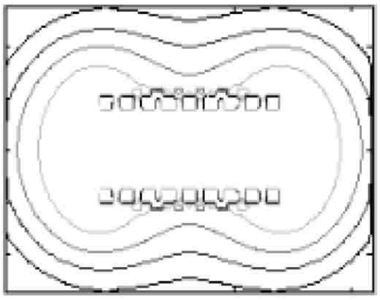

Figure 5. Gray Segmented Image.

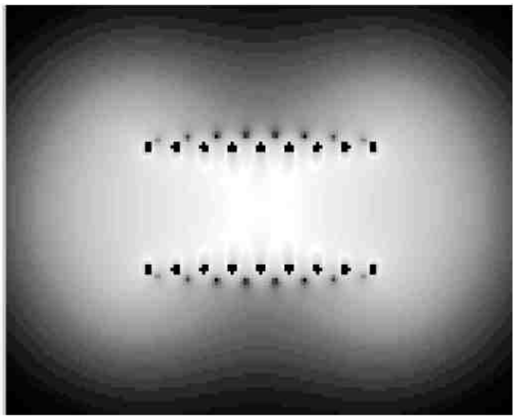

Figure 6. HGAMBHE Output.

In Figure 5, it is observed that the low contrast image is segmented and then gives better quality of image as shown in Figure 6 using proposed technique HGAMBHE.

BHE method can be used in case of asymmetric images also, but the generated result is not so good [3]. This problem is solved by the present proposed method of HGAMBHE. This method has a very good impact on any images. To prove this a test image is considered and both HGAMBHE and BHE are applied on it. The comparative study of the image is shown in Figure 7 and Figure 8.

Figure 7. Bi-Histogram Equalization output on test image.

Figure 8. HGAMBHE Output.

It can be clearly observed that in Figure 8, the brightness preservation and contrast enhancement is better than that in Figure 7. Figure 8 shows the output of HGAMBHE.

Figure 9. Input test_3.

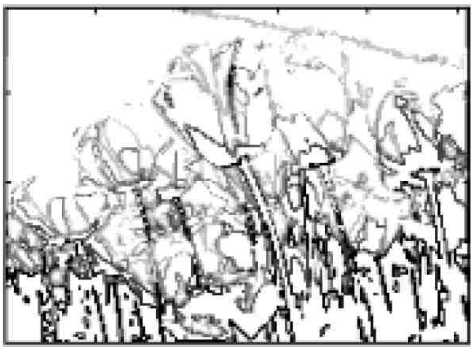

Figure 10. Segmented output of input test_3.

Figure 11. Bi-Histogram equalization of output test_3.

Figure 12. HGAMBHE output of test_3.

In the above Figure 11 and Figure 12, it is observed by bare eye and distinguished the quality of images using Bi-Histogram Equalization (BHE) and Hyper Geometrically Absolute Mean Bi-Histogram Equalization (HGAMBHE), respectively. The input test_3 image is taken (shown in Figure 9) and gray level of the segmented image output is shown in Figure 10. Input test_3 image is named as Tulips and the detail parameter calculation results of PSNR value and AMM value are listed in Table 1 and 2, respectively.

The PSNR value and AMM value for BHE image and HGAMBHE image is shown below.

Calculation of PSNR and AMM values are done and shown in Table 1 and Table 2, respectively.

Table 1. Comparison of PSNR values

Figure Name	BHE	HGAMBHE
Bedroom	4.7965	5.7843
Beach	4.8280	5.7087
Spiral	4.8143	12.9842
Dice	4.8004	7.4274
Solenoid	4.8181	9.5544
Subway	4.8207	8.7481
Tulips	4.8164	6.5059
Board	4.7900	6.6906

Table 2. Comparison of AMM values

Figure Name	BHE	HGAMBHE
Bedroom	0.5158	0.0408
Beach	0.6512	0.0303
Spiral	0.4625	0.0212
Dice	0.6545	0.0489
Solenoid	1.0319	0.0919
Subway	0.7527	0.0423
Tulips	0.4075	0.0301
Board	0.5158	0.0408

The above value clearly shows that the HGAMBHE image is better than the BHE image in every respect. The brightness of the any input image is properly preserved as the AMM values are very small and contrast enhancement is also better as the PSNR values are higher.

5. Conclusion

The Hyper Geometrically modified absolute mean proposed in this paper is better than any other existing histogram equalization technique which clear from the calculated values of various metrics. The value of PSNR obtained from HGAMBHE is more as compared to other histogram equalization techniques such as Histogram Equalization and Bi-Histogram equalization. This implies that the amount of noise that has been removed from HGAMBHE is more than the noise removed from any other HE techniques. Also, the enhancement produced from hyper geometrically modified absolute mean bi-histogram equalization technique is more natural than the enhancement produced from histogram and bi-histogram equalization techniques. In other words, the HGAMBHE produces better results and is also suitable for images with asymmetric pixel intensity distribution and produces enhancement with better quality for any image.

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