Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 4, Issue. 1, January 2015, pg.314 – 319

RESEARCH ARTICLE

A Comparison of Thresholding Based Image Enhancement Techniques

Rajat Butola[1], Sparsh Pratik[2], Upendra Kumar*

[1]Department of Electronics & Communication, Amity University Haryana, India

[2]Department of Electronics & Communication, Amity University Haryana, India

[*]Department of Electronics & Communication, Amity University Haryana, India

Email Id- [1] rajatbutola@gmail.com, [2] sparshpratik@gmail.com, [*] upendrakumariitk@gmail.com

Abstract - Image Enhancement is a vast area of Image Processing with its applications in different areas. Image Enhancement is used to transform digital images to enrich the visual information inside it. It is an initial operation for almost all vision and image processing assignment in several areas such as computer vision, biomedical image Processing, forensic image analysis, remote sensing and fault detection. In image enhancement certain transformations are applied upon an input image to obtain a visually more acceptable, more comprehensive and less noisy output image. In this paper four histogram equalization based Image Enhancement Techniques, CHE (Conventional Histogram Equalization), BBHE (Brightness Preserving Bi-Histogram Equalization), DSIHE (Dual Sub-Image Histogram Equalization) and MMBEBHE (Minimum Mean Brightness Error Bi-HE), are compared. All these techniques are based on partitioning of histogram of image and then equalizing each part separately. These techniques are assessed qualitatively and after examining output image visually, we see if it retains an appearance which is perfectly natural.

Keywords: BBHE, Brightness, DSIHE, Histogram Equalization, MMBEBHE, Thresholding Technique.

1 INTRODUCTION

Image Enhancement is a primary but challenging problem in Image Processing. It is a very effective and useful technique to increase the visual quality of the input image so that the appearance of output image becomes more acceptable and satisfactory than the original one. Several image enhancement techniques have been presented in both the spatial and frequency domains [7]. In spatial domain we analyse the image pixels and change their values to obtain the desired enhancement whereas in frequency domain techniques, the frequency transform domain coefficients are modified [1], [9]. So in Image enhancement a certain transformation is applied to an input image to obtain a perceivably more satisfying, more contented, or less noisy output image. To enhance Digital Images, Histogram Equalization is very simple and most widely used Image Enhancement Technique [11]. The Histogram of a digital image with intensity levels in the range [0, L-1] is a discrete function h(rk) = nk, where rk is kth intensity value and nk is the number of pixels in the image with intensity rk. The operation of HE is achieved by rearranging the gray levels of the image based on the probability distribution of the input gray levels [8]. When we apply HE in a digital image it simply distributes all the pixels equally throughout the gray level range. So after HE each gray level has almost equal number of pixels. So the mean of image is always middle gray level in spite of the nature of image i.e. whether the image is a dark image or bright image [10]. Actually this is the main drawback of Histogram Equalization technique that it shifts the mean of output image regardless the mean of input image. In effect the mean of histogram equalized image is always the middle gray level.

So if HE is applied in those images which have background either completely dark or completely bright the mean changes drastically and image experience unnatural changes. This reduces the quality of image further instead of enhancing it. So merely applying Histogram Equalization blindly in all images does not solve the purpose. Therefore when HE is applied in digital images the aim should be to retain the mean of the output image.

Some improved histogram equalization have been introduced such as Brightness Preserving Bi-histogram Equalization (BBHE), Dualistic sub-image histogram equalization (DSIHE) and Minimum Mean Brightness Error Bi-histogram Equalization (MMBEBHE), which enhance the quality of image and also preserve the mean.

In BBHE the histogram of input image is divided into two equal parts based on input mean. The input mean is called threshold point. Each part is then equalized separately and the above problem of brightness preservation is resolved [6]. In DSIHE input image's histogram is separated in two parts from the point where each part has equal area or image pixels. MMBEBHE is the novel extension of BBHE that provides maximum brightness preservation. These techniques are upgraded version of conventional histogram equalization, which utilize separate equalizations of sub-images obtained by decomposing the input image.

2 HISTOGRAM EQUALIZATION TECHNIQUES

2.1 Conventional Histogram Equalization (CHE)

Histogram equalization is a simple and effective method for image enhancement. Based on the original gray level distribution of image, histogram of the image is reshaped into a different one with uniform distribution property in order to increase the contrast [19]. The essentiality of histogram equalization is to decrease the number of gray levels so that the contrast of the image can be enhanced.

Let X = { X (i ,j) } denote a given image composed of L discrete gray levels denoted as:

$$\{X_0, X_1, \dots X_{L-1}\}$$

where X (i , j) represents an intensity of the image at the spatial location (i , j)

and $X(i,j) \in \{X_k, X_1, \dots\dots X_{L-1}\}$.

For a given image X, the probability density function $p(X_k)$ is defined as

$$p(X_k) = \frac{n_k}{n}$$

for k = 0 , 1 , . . . , L - 1, where n_k represents the number of times that the level X_k appears in the input image X and n is the total number of samples in the input image [23][19]. Note that $p(X_k)$ is associated with the histogram of the input image which represents the number of pixels that have a specific intensity X_k. The plot of n_k vs X_k is known as the histogram of X. Based on the PDF (probability density function), we describe the cumulative density function as:

$$c(x) = \sum_{j=0}^{k} p(X_j)$$

One drawback of the histogram equalization can be found on the fact that the brightness of an image can be changed after the histogram equalization, which is because of the flattening property of the histogram equalization. The mean of the output image after histogram equalization will always approach to central gray level value regardless the value of input mean. Thus, it is rarely utilized in consumer electronic products such as TV where preserving original input brightness may necessary in order not to introduce unnecessary visual deterioration.

2.2 Brightness Preserving Bi-Histogram Equalization (BBHE)

A novel extension (Brightness Preserving Bi-Histogram Equalization) of histogram equalization is proposed to overcome such drawback of the histogram equalization. The essence of BBHE algorithm is to utilize independent histogram equalizations separately over two sub images (Fig.1) obtained by decomposing the input image based on its mean with a constraint that the resulting equalized sub-images are bounded by each other around the input mean [3]. It will be shown mathematically that the proposed algorithm preserves the mean brightness of a given image significantly well compared to typical histogram equalization while enhancing the contrast and, thus, provides much natural enhancement that can be utilized in consumer electronic products. Denote by X_m , the mean of the image X and assume that

$$X_m \in \{ X_o, X_1, \ldots\ldots X_{L-1} \}$$

based on the mean, the input image is decomposed into two sub images X_L and X_U as

$$X = X_L \cup X_U.$$

Note that the sub image X_L is composed of:

$$(X_o, X_1, \ldots\ldots X_m,)$$

and the other sub image X_U is composed of :

$$(X_{m+1}, X_{m+2}, \ldots\ldots X_{L-1})$$

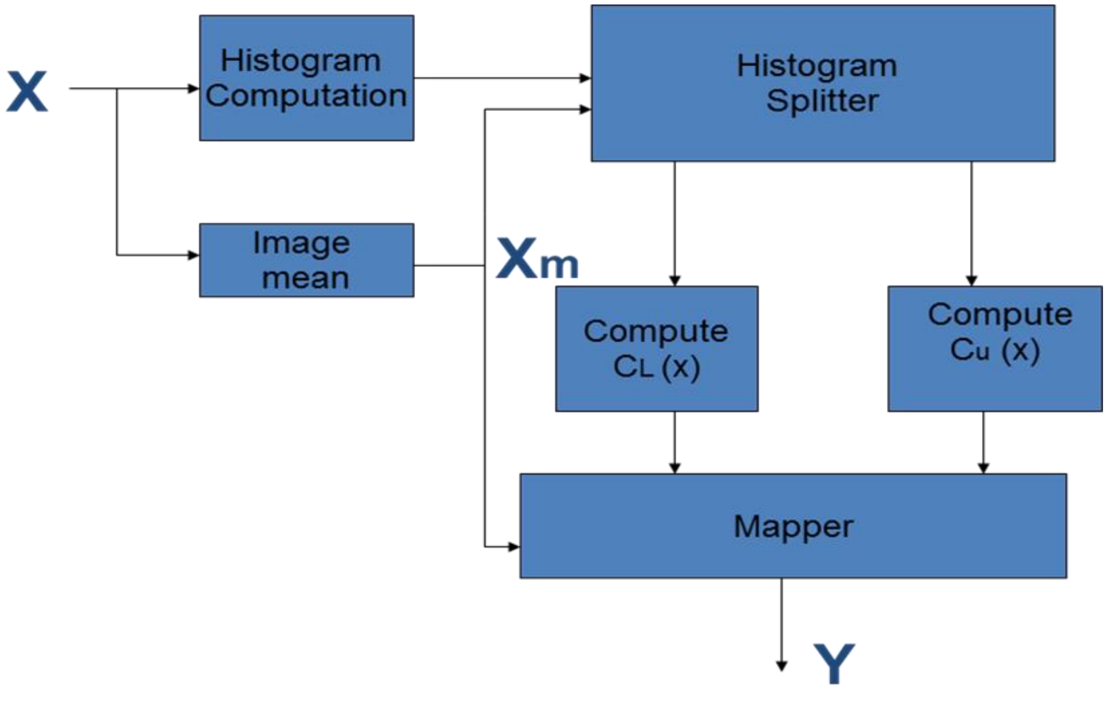

Fig. 1. The Functional Block Diagram of the BBHE

Similar to the case of histogram equalization where a cumulative density function is used as a transform function, let us define the following transform functions exploiting the cumulative density functions

$$f_L(x) = X_0 + (X_m - X_0)\, C_L(x)$$

and

$$f_U(x) = X_{m+1} + (X_{L-1} - X_{m+1})\, C_U(x)$$

Based on these transform functions, the separated sub images are equalized independently and the composition of the resulting equalized sub images constitutes the output of the BBHE. That is, the output image of the BBHE, Y, is finally expressed as:

$$Y= f_L(X_L) \cup f_U(X_U)$$

If we note that $0\leq C_L(x)$, $C_U (x) \leq 1$ it is easy to see that $f_L(X_L)$ equalizes the sub image X_L over the range (X_0, X_m) whereas $f_U(X_U)$ equalizes the sub image X_U over the range (X_{m+1}, X_{L-1}). As a consequence, the input image X is equalized over the entire dynamic range (X_0, X_{L-1}) with the constraint that the samples less than the input mean are mapped to (X_0, X_m) and the samples greater than the mean are mapped to (X_{m+1}, X_{L-1}).

2.3 Dualistic Sub-Image Histogram Equalization (DSIHE)

In this technique also we do the same thing as in BBHE, but here the original image is segmented into two equal area sub-images based on its gray level probability density function [5]. After that the two sub-images are equalized independently, and then we get the resultant image after the processed sub-images are composed into one image. This algorithm not only effectively enhances the image visual information, but also constrains the original image's average brightness from great shift. That makes it possible to be utilized in video system directly.
Assuming that image X is decomposed by a section with gray level of $X=X_T$, and the two sub-images are X_L, and X_U, Where

$$X_L = \{X(i, j) \mid X(i, j) > X_T, \forall X(i, j) \in X \}$$

and

$$X_U = \{X(i, j) \mid X(i, j) \geq X_T, \forall X(i, j) \in X \}$$

The rest calculations will remain same as in previous technique.

2.4 Minimum Mean Brightness Error Bi - Histogram Equalization (MMBEBHE)

However, there are still cases that are not handled well by BBHE, as these images require higher degree of preservation [4]. A novel extension of BBHE referred to as Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) is proposed to provide maximum brightness preservation. BBHE separates the histogram of the input image into two based on input mean before equalizing them independently. But in this technique the separation is done by the threshold level, which gives minimum Absolute Mean Brightness Error (AMBE - the absolute difference between input and output mean). An effective recursive integer-based computation for AMBE has been formulated to facilitate real time implementation [5]. Simulation outcomes using

sample image which represent images that have too low, too high and medium mean brightness show that the cases which are not managed

well by HE, BBHE and Dualistic Sub Image Histogram Equalization (DSIHE), can be properly enhanced by MMBEBHE [4].

2.4.1 Algorithm for MMBEBHE

1. Calculate the AMBE for each of the threshold level as:

$$AMBE = | E(X) – E(Y) |$$

2. Find the threshold level, X_T that yield minimum AMBE.
3. Separate the input histogram into two based on the XT found in step 2 and equalized them independently as in BBHE.

3. Result & Discussion

The previous sections describes methods which use Histogram Equalization for preserving the brightness of gray-level images and also enhance the contrast. Now Fig.2 below shows, for the input images, the output images and respective histograms produced by these HE methods.

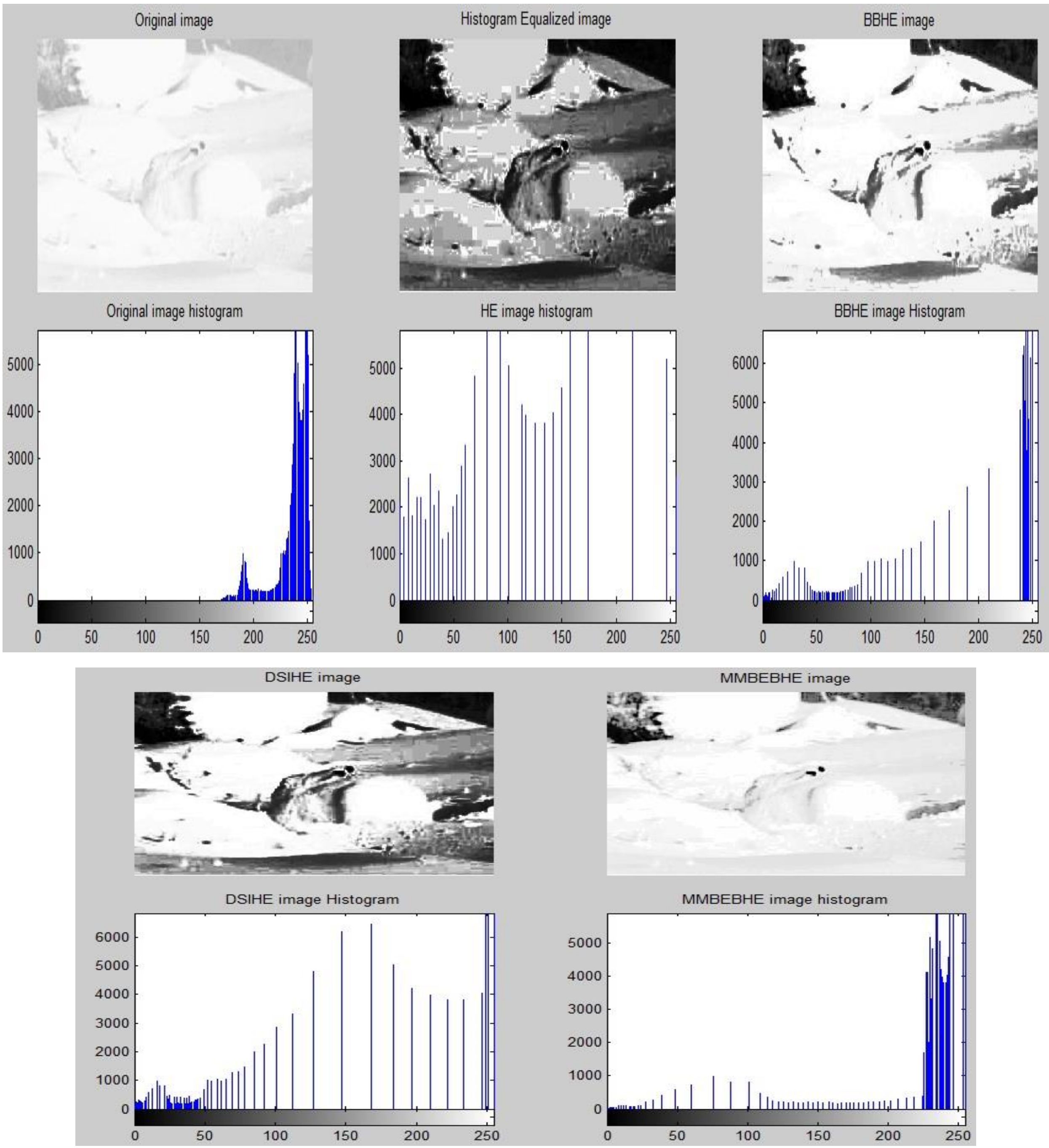

Fig 2 : Shows the Images and Histograms of Original Image Ice and comparative results of HE, BBHE, DSIHE and MMBEBHE Image.

The major goal of the qualitative assessment is to judge if the output image is visually acceptable to human eyes and has a natural appearance. To find out the performance of the proposed algorithm above, simulation results of CHE, BBHE, DISHE and also MMBEBHE for images Ice are presented.

4. CONCLUSION

We see above contrast enhancement algorithms referred to as BBHE and DSIHE is simulated. These techniques are novel extension of typical histogram equalization. They equalize histogram of image independently over two sub images obtained by decomposing the input image. The ultimate goal behind the BBHE and DSIHE is to preserve the mean brightness of a given image while enhancing the contrast of the image. The simulation results shown above indicate that MMBEBHE better preserve the brightness than HE, BBHE and DSIHE.

So, it is noticed that the cases where the background is completely dark or bright, and are not handled well by HE, BBHE and DSIHE the MMBEBHE gives better result. These types of images generally require higher degree of brightness preservation to avoid annoying artefacts. MMBEBHE provides better brightness in these cases. The main idea lies on separating the histogram using the threshold level that would yield minimum Absolute Mean Brightness Error (AMBE). The ultimate goal behind the MMBEBHE is to allow maximum level of brightness preservation in Bi-Histogram Equalization to avoid unpleasant artefacts and unnatural enhancement due to excessive equalization while enhancing the contrast of a given image as much as possible. MMBEBHE demonstrate comparable performance with HE, BBHE and DSIHE.

REFERENCES

[1] R. C. Gonzalez and R. E. Woods, ‘Digital Image Processing’, 2nd Ed., Prentice Hall, 2002.

[2] K.Yeong-Taeg, ‘Contrast Enhancement Using Brightness Preserving Bi-Histogram Equalization’, IEEE Transactions on Consumer Electronics, Vol. 43, No. 1, pp. 1-8, 1997.

[3] Soong - Der Chen, A. R. Ramli, ‘Minimum Mean Brightness Error Bi-Histogram Equalization in Contrast Enhancement’, IEEE Transactions on Consumer Electronics, Vol. 49, No. 4, NOVEMBER 2003.

[4] S. D. Chen, and A. R. Ramli, ‘Contrast Enhancement using Recursive Mean-Separate Histogram Equalization for Scalable Brightness preservation’, IEEE Transactions on Consumer Electronics, Vol. 49, No. 4, pp.1301-1309, 2003.

[5] W. Yu, C. Qian, and Z. Baeomin, ‘Image Enhancement Based on Equal Area Dualistic Sub-Image Histogram Equalization Method,’ IEEE Transactions on Consumer Electronics, vol. 45, no. 1, pp. 68-75, 1999.

[6] G. Park, H. Cho, and M. Choi, ‘A Contrast Enhancement Method using Dynamic Range Separate Histogram Equalization’, IEEE Trans, 2008.

[7] Maini. R. and A. Himanshu, ‘A Comprehensive Review of Image Enhancement Techniques’, Journal of Computing, Vol 2, Issue 3, MARCH 2010,

[8] T.Singh., and Nagraja .M, ‘Enhancing Image Contrast of Mammogram & Equalization of Histograms’ International Journal of Engineering Science and Technology, Vol. 3 No. 1 Jan 2011

[9] V. Govind, Arun, A. Balakrishnan and D. Mathew, “A Novel Approach for Contrast Enhancement and Noise Removal of Medical Images,”accepted in 2013 International Conference on Control, Communication and Computing (ICCC 2013), College of Engineering, Trivandrum, 13 – 15 December 2013.

[10] P. Welling. S.H. Kim, S and B. Cho, “Brightness Preserving Contrast Enhancement using Polynomial Histogram Amendment”accepted in 2012 SoC Design International Conference (ISOCC), pp. 41 – 44, 4-7 Nov. 2012.

[11] Chauhan, Ritu, and Sarita Singh Bhadoria. "An improved image contrast enhancement based on histogram equalization and brightness preserving weight clustering histogram equalization." Communication Systems and Network Technologies (CSNT), 2011 International Conference on. IEEE, 2011.

