A Survey on Image Enhancement by Histogram equalization Methods

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Abstract – ***Image enhancement can be used to improve visual appearance of picture. For contrast enhancement, Histogram equalization technique is used. Histogram equalization is used to preserve the better brightness of picture. We have studied about various techniques of histogram equalization like Brightness Preserving Bi-Histogram Equalization, Dualistic Sub-Image Histogram Equalization, Minimum Mean Brightness Error Bi-Histogram Equalization, Recursive Mean–Separate Histogram Equalization, Mean Brightness Preserving Histogram Equalization, Dynamic Histogram Equalization, Brightness Preserving Dynamic Histogram Equalization are various techniques of histogram equalization. Minimum Mean Brightness Error Bi-Histogram Equalization is better than other techniques to preserve the brightness of picture as this technique can be modified and provides enhanced images with enhancing resolution of images.***

KeyWords: contrast, *BPBHE*, *DHE*, enhancement, *MMBEBHE*, *BPDHE*, equalization, *DHE*, *MMBEBHE*, histogram, *RMSHE, DSIHE, MBPHE*.

1. INTRODUCTION

In digital image processing, image is a collection of pixels that are arranged in columns and rows. Images are divided into two groups: vector images, bitmaps images [1]. Digital image is defined as the binary representation of two dimensional images. Digital images are of bitmapped type. Each image uses file formats.

In digital image processing, picture enhancement is used to improve appearance of picture. Contrast image enhancement plays important role in image enhancement. There are two types of approaches for contrast picture enhancement. This is shown as Context-Sensitive and Context-Free [2][5]. In Contrast-Sensitive methodology, differentiation is characterized as far as rate of progress in force between neighboring pixels. This is inclined to antiquities, for example, ringing and amplified noise. In Context-Free methodology, it does not alter the nearby waveform on a pixel by pixel basis. Picture enhancement is done by histogram equalization for improving the contrast [6][7]. There are also other methods such as Contrast Stretching, *BPBHE, DSIHE* and *CLAHE* used for brightness picture enhancement. Histogram equalization is the standout amongst the most prevalent, computational quick and easy to implement [3]. Numerical data is distributed graphically that is called Histogram [4]. The quantity of pixels in a picture can be graphically distributed that is called picture histogram. It plots quantity of each pixel for each tonal value. Histogram of given image is stretched by histogram equalization [8]. If histogram stretch is greater than contrast of image is also greater. As the contrast of picture is increased then it implies that histogram dispersion of that picture should be expanded. Histogram can be taken of grey scale images as well as color images. There are 256 different possible intensities for 8 bit grey scale pictures. For color pictures, 3D histogram is produced. Histogram can be taken individually for red, green and blue channels. The accurate output from the operation relies on its usage; it might be an information record. In order to uniformly distribute intensities in output picture, Histogram Equalization approach can be used to remap the grey level in picture [9].The scope of picture histogram is expanded by histogram equalization. There are few cases that are not overseen by *BHE* particularly during executing digital images. Histogram of output image is transformed into flat uniform histogram using histogram techniques [10]. For pictures with high and low resolution, it implies a change in picture outlook at the cost of improving the contrast. For improving the histogram equalization based contrast enhancement, many variations are made such as brightness preserving bi-histogram equalization (*BPBHE*), dualistic sub-image histogram equalization (*DSIHE*), and minimum mean brightness error bi-histogram equalization (*MMBEBHE*).In *BBHE*, image histogram is divided into two parts. In *BBHE*, separation intensity is represented by input mean brightness value. Input mean value is sum of all pixels that are constructed the input picture [11]. After this, these two histograms are freely leveled. *DSIHE* takes same thoughts as followed *BPBHE* to divide the original picture into two sub-pictures and then balances the histogram-pictures independently, proposed the *DSIHE* method. *MMBEBHE* is variation of *BPBHE* that is used to preserve the maximum brightness. *BPBHE* has variation that is Reverse Mean-Separate Histogram Equalization.

2. HISTOGRAM EQUALIZATION (HE)

It is the mostly used methodology for contrast enhancement. In this, pixel values of input picture are matched to produce picture that has uniform histogram as possible. It allows area of less brightness to produce high brightness. It is globally increased the brightness of pictures. Intensity values can be easily conveyed on histogram by using contrast adjustment method [12][13][17]. *HE* decides a transform function that is seeking to give a yield picture with uniform histogram.

For a given picture, likelihood thickness capacity

$P(xk) = nk/n$ (1)

For k=0, 1 ...L-1, where nk is represented the quantity of times. Level xk is shown up in the information picture x and n is total number of tests in the data image [4][5]. Note that P(xk) is connected to the histogram of the info picture. It denotes the quantity of pixels that have particular force xk based on the likelihood thickness capacity. *HE* is a method that matches information picture into whole element range(x_0,x_{L-1}) by using total thickness capacity as a transform function. *HE* also straightens a histogram. Highest value will get by entropy of message source. There are many Histogram Equalization schemes such as:

2.1 Brightness Preserving Bi-Histogram Equalization (BPBHE)

In this approach, histogram of picture is divided into two parts. In it, input mean brightness value is introduced by division intensity, which is normal power of all pixels that build the data picture [18].After this division, these two histograms are leveled independently. After doing this, mean brightness of output picture will lie between info mean and centre grey level. Histogram with limit 0 to L-1 is partitioned into two parts. Two histograms are produced by this partition .The first has scope of 0 while second has scope of L-1 out of these two histogram.

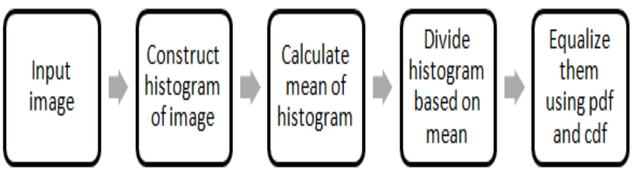

Fig1. Process of BPBHE

2.2. Dualistic Sub-Image Histogram Equalization (DSIHE)

Same idea of *BPBHE* is taken by this method. It divides the first picture into two sub-pictures, which balances the histograms of sub pictures individually [6]. Rather than dividing the picture based on its mean grey level, to make one dark and one bright, is regarding the equivalent area property [19]. In it, brightness of data picture is defined as normal of equivalent area level of picture 'I' and centre gray level of picture. Authors assert that brightness of yield picture produced by *DSIHE* method has not introduced an important movement in relation to contrast of the data picture, particularly for vast zone of picture with equal grey levels [15][23].

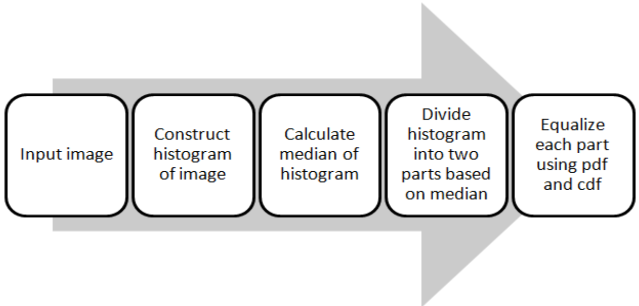

Fig2. Process of DSIHE

2.3 Minimum Mean Brightness Error Bi-HE Method (MMBEBHE)

Same idea of *DSIHE* to decaying a picture is taken by *MMBEBHE* and resulting sub-pictures are independently equalized using HE [3] [7]. Threshold level finds by *MMBEBHE* that divides the picture I into two sub-pictures I [0, l_t] and I[l_t+1,L-1], such that minimum shine distinction between data picture and yield picture is defined as absolute mean brightness error(AMBE),AMBE=|E(X)-E(Y)|. Data and yield picture is denoted as X and Y. Brightness is better saved when AMBE is shown less. Once the information picture is divided by threshold level l_t, each of these two sub –pictures I[0,l_t], and I[l_t+1.L-1] has its histograms equalized using classical HE process, producing data picture [23][24]. *MMBEBHE* is formally characterized by following:

(1) For each of possible threshold edges, AMBE is calculated.

(2) In order to obtain lower level of AMBE, limit level of X_t is found.

(3) Data histogram is divided into two on basis of X_t found in Step 2 and are equalized freely as in *BBHE*.

2.4 Recursive Mean –Separate HE Method (RMSHE):

Another developed version of *BBPHE* is the *RMSHE*. Before preserving the original brightness of a picture, BBPHE is performing mean separation. Instead of decomposing picture only once, *RMSHE* is performing picture decomposition recursively. *RMSHE* preserves original contrast of picture upto r. Level 0 of *RMSHE* is equal to *HE*. Level of *RMSHE* with value r=1 is equal to *BBPHE*. As the value of r increases, brightness of yield picture is preserved better.

2.5 Mean Brightness Preserving Histogram Equalization (MBPHE):

Bisections *MBPHE* and multi-section *MBPHE* are two groups of *MBPHE*. Simple group of *MBPHE* is the bisections *MBPHE* [3]. Input histogram is divided into two parts using both of the methods. Equalization of these two histogram parts is done freely. Mean brightness is preserved only to a certain point using bisections *MBPHE*. In order to avoid unpleasant artifacts, some cases are required to preserve higher degree. If input histogram has quasi-symmetrical separation around its different points then bisections *MBPHE* preserves only mean brightness. But this property is not required by most of the input histograms [14][22]. Bisections *MBPHE* is failing in preserving mean intensity due to this condition. As compared to bisections *MBPHE*, multi-sections *MBPHE* is better in preserving mean brightness. Input histogram is divided into 'R' histograms in multi-sections *MBPHE* where 'R' is integer value. Equalization is done freely for each of the sub-histogram. Shape of input histogram is affected the creation of sub-histograms. Complicated algorithms are required for detection of separating point process in which highly computational time is required. Hardware requirements are increased during implementations using these methods. As a consequence, these methods do not give much enhancement [22].

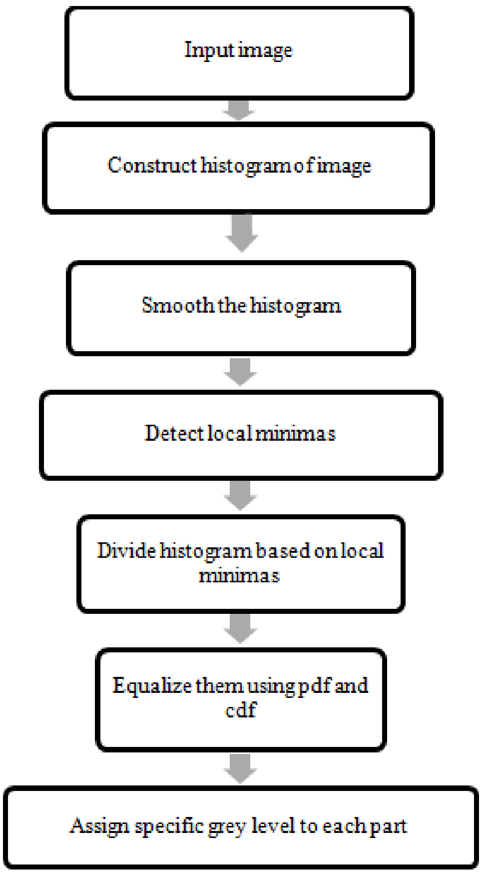

Fig3. Process of MBPHE

2.6 Dynamic Histogram Equalization (DHE)

Dynamic Histogram Equalization is performing enhancement of picture without losing details of it. It divides the input histogram into sub-histograms until newly constructed sub-histograms has not dominating part that is presented in it. Dynamic grey level is to each of sub-histogram which is then mapped by *HE*. Total available dynamic grey level is partitioned between sub-histograms on basis of their dynamic range in input picture and *CDF* values of histograms. Small features of input picture are prevented from being dominated and washed out by stretching limit of contrast. Separate transformation function is calculated for each of sub-histogram on basis of traditional *HE* technique and grey levels of both input and yielding picture that are mapped. By partitioning histogram, whole technique is divided into three parts.GL ranges are allocated to each of sub histogram and *HE* is applied on each of them [20][21].

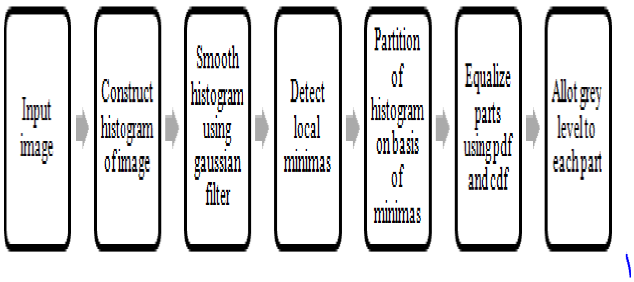

Fig4.Process of DHE

2.7 Brightness Preserving Dynamic Histogram Equalization (BPDHE)

The brightness preserving dynamic histogram equalization is an extended form of *HE*. Mean contrast of picture is maintained by *BPDHE.* The mean intensity of both yield picture and input picture are almost equal. *DHE* has variation that is called *BPDHE* [3].Depend on local maximums of smoothed histogram, histogram is partitioned. In this method, each part will be mapped to new dynamic range before histogram equalization has taken place. Mean brightness will be changed due to change in dynamic range. The final step of *BPDHE* is normalization of output intensity. *BPDHE* is produced better enhancement and preserved better mean brightness as compared to *DHE [22]*.

3. Problems in Histogram equalization:

1. Mean brightness of picture is not considered into account using histogram equalization.

2. Due to expand grey levels over full grey level range, HE approach may be result in over enhancement and concentration artifacts.

3. After applying the histogram equalization, it is possible to change brightness of picture.

4. Because of changing the brightness and unwanted artifacts, HE method is not used in consumer electronics such as TV.

5. Rather than observing the histogram equalized picture is middle gray level, it is observed that histogram equalized picture is always middle gray level.

Table1. Comparison between different histogram equalization techniques

Parameters	**BPBHE**	**DSIHE**	**MMBEBHE**	**RMSHE**	**MBPHE**	**DHE**	**BPDHE**
Losses	It fails to control overall enhancement of picture due to which some information is loss.	It is not able to keep luminance in some cases.	It is slowly and caused annoying side effects due to variation in grey level values.	Loss of information is less.	It does not provide good enhancement due to too much constrains on mean intensity value.	It does loss any information.	In it, loss of information is less.
Noise	Noise is less .	It causes noise as compared to BPBHE	Less noise	Less	-	High noise	No Noise
Brightness Preservation	Preserves overall mean brightness of original input picture	It provides good brightness.	It provides maximal brightness preservation.	Better and scalable brightness preservation	It does provide better brightness preservation.	Moderate brightness preservation	It provides better brightness preservation as compared to DHE.
SNR	Moderate			More			
Complexity	Low complexity			Moderate complexity	It requires complexity due to complicated algorithms	It increases complexity.	
Processing Time	It has fast processing time.			More processing time	More		

4. Metrics for Gray Scale Images:

1. **Peak Signal to noise ratio:** The important measurement feature is PSNR. It is the assessment standard to reproduce picture quality. Decibels (db) are used to measure PSNR. It is represented by:

$$PSNR= 10\log (255^2/MSE)$$

where highest value, that is attained by picture signal, is value 255.Where M*N is size of input picture, it is defined as MSE. As the PSNR value is increased, reproduce picture is better.

2. **Absolute Mean Brightness Error:** AMBE is defined as difference between input and enhanced picture. It is represented as:

$$AMBE=|E(x)-E(y)|$$

where the average intensity of input picture is given by E(X),the average intensity of enhanced picture is given by E(Y).

3. **Contrast:** Contrast differentiates the lower and higher level. The higher value of contrast is shown by difference between lower and higher intensity level.

4. **Visual Quality:** It is easy to define the difference between original and enhanced picture after looking at enhanced picture.

5. CONCLUSION

In this paper, we have studied about different methods of histogram equalization. All methods are compared with each other based on different parameters such as noise, brightness preservation, *SNR* and computational time. *HE, BBPHE, DSIHE* does not handle the higher brightness preservation. *RMSHE* is extended form of *HE, BBPHE, DSIHE*. *MMBEBHE* preserves maximum brightness. Thus it is observed that all histogram equalization techniques have their merits and demerits based on various performances metrics according to quality of the image. Thus these techniques can be improved and modified to get more refined images.

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