A COMPARATIVE STUDY OF HISTOGRAM EQUALIZATION TECHNIQUES FOR IMAGE CONTRAST ENHANCEMENT

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Abstract

The most significant outcome of image processing is a contrast enhancement. The most usual method of histogram equalization is used for mending contrast in digital images. Histogram equalization is so convenient and efficacious for image contrast enhancement technique. However, the conventional histogram equalization techniques usually outcome in exceeding contrast enhancement which factor the non-natural look and visible artefact of the processed image. In this paper presents a different new form of histogram for image contrast enhancement. Several methods are this establishment is the measuring used to impart the input histogram. Global Histogram Equalization GHE uses the intensity distribution of the entire image. Brightness preserving Bi-Histogram Equalization BBHE uses the mean intensity is equalized image independently. Dual Sub-Image Histogram Equalization DSIHE uses the median intensity is equalized image independently. Minimum Mean Brightness Error Bi-HE MMBEBHE uses the separation of image based on threshold level, produces the smallest Absolute Mean Brightness Error AMBE. Recursive Mean-Separate Histogram Equalization RMSHE is more different advance method of histogram equalization. Range Limited Bi-Histogram Equalization RLBHE preserves the first brightness quite well so as to separate the threshold that minimizes the intra –class variance. Survey same that everyone these strategies are more simple and useful for image contrast enhancement.

Index Terms: *Image Contrast Enhancement, Histogram Equalization, Brightness Preserving Enhancement, Range Limit, Histogram Partition.*

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1. INTRODUCTION

Image enhancement could be process involving changing the pixels' intensity of the input image, so that the output image should subjectively look better [1]. The goal of image enhancement is to improve the interpretability of information contained in image for human viewer, or to produce a "better" input for different automated image processing system. A very popular technique for image enhancement is histogram equalization (HE) [8]. Histogram equalization is wide used for contrast enhancement during a sort of application attributable to its easy perform and effectiveness. One downside of the histogram equalization may be found on the very fact that brightness of a picture can be modified when histogram equalization that is especially attributable to the flattening property of the histogram equalization [2]. Global histogram equalization (GHE) is one in all the foremost usually used ways for image contrast enhancement because as a result of its high potency and simplicity. It's achieved by normalizing the intensity distribution victimization its cumulative distribution functions in order that the result image could have a uniform distribution of intensity [3]. However, since GHE is largely victimization the intensity distribution of the complete image, it should suffers from major drawbacks like over enhancement, increase in the noise level, lost in detail and washed-out effect in some almost homogeneous area [1].

In the recent years, several researchers proposed numerous helpful algorithms to resolve these issues concerned in GHE technique. These some ways are Brightness preserving Bi-Histogram Equalization (BBHE) [2], Equal Area Dualistic Sub-Image Histogram Equalization (DSIHE) [4] and Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) [5], etc. BBHE divides the input image histogram into two parts supported the mean of the input image and so every half is equal severally. It's been analyzed each mathematically and through an experiment that this system is capable to preserve the first brightness to particular extents. The DSIHE methodology is analogous to BBHE except that it separates the histogram supported the median value. MMBEBHE is another extension of BBHE that has highest brightness preservation by victimization the threshold level, which might yield minimum distinction between input and output mean. Though these ways will perform sensible contrast enhancement, they conjointly cause a lot of annoying facet effects reckoning on the variation of grey level distribution within the histogram. Conjointly RMSHE (Recursive Mean-Separate Histogram Equalization) [9] and RSIHE (Recursive Sub-Image Histogram Equalization) [10] are recursive algorithms of BBHE and DSIHE. These two recursive ways have improved results scrutiny with previous ways. The mean brightness of the output was just like that of the input in RMSHE and RSIHE. However, the equalization result was reduced.

A new bi-histogram equalization algorithm is referred to as Range Limited Bi-Histogram Equalization (RLBHE) [8]. This methodology takes both contrast improvement and brightness preservation under consideration. To realize higher contrast enhancement and avoid over enhancement, Otsu's methodology [7] is employed to perform histogram threshold. Then we tend to limit the range of the equal image to ensure that the mean output brightness can be almost equal to the mean input brightness [8].

2. GLOBAL HISTOGRAM EQUALIZATION

Let us suppose that X = {X (i,j)} denotes a digital image, where X(i,j) denotes the gray level of the pixel at (i,j) place. The total number of the image pixels is n, and the image intensity is digitized into L levels that are $\{X_0, X_1, X_2 \ldots X_{L-1}\}$. So it is obvious that $\forall X(i,j) \epsilon \{X_0, X_1, X_2, \ldots X_{L-1}\}$.Suppose n_k denotes the total number of pixels with grey level of X_k in the image, then the probability density of X_K will be

$$p(X_k) = \frac{n_k}{n}, \quad k=0,1,\ldots\ldots,L-1 \tag{1}$$

The relationship between $p(X_k)$ and X_k is defined as the probability density function (PDF), and the graphical appearance of PDF is known as the histogram. Based on the image's PDF, its cumulative distribution function is defined as

$$C(X_k) = \sum_{j=0}^{L-1} p(X_j) = \sum_{j=0}^{L-1} \frac{n_k}{n} \tag{2}$$

Where k=0, 1, ………., L-1, and it is obvious that $c(X_{L-1})=1$. Let us define a transform function f(x) based on the cumulative density function as

$$f(x) = X_0 + (X_{L-1} - X_0)c(x) \tag{3}$$

Then output image of the GHE, **Y** ={Y(i,j)}, can be expressed as

$$\mathbf{Y} = f(x) = \{f(X(i,j) \forall X(i,j) \epsilon \mathbf{X}\} \tag{4}$$

The output grey level **Y** follows the uniform distribution. Suppose that **X** is a continuous random variable.

$$p(y) = \frac{1}{X_{L-1} - X_0} \tag{5}$$

Thus, it is easy to show that the mean brightness of the output image of the HE

$$E(\mathbf{Y}) = \int_{X_0}^{X_{L-1}} y p(y)\, dy \tag{6}$$

The output mean of the HE does not take the mean brightness of the original image into account [8].

3. BI-HISTOGRAM EQUALIZATION

These strategies separate input histogram into two subsections. These two elements equalized severally. During this methodology the factors accustomed selected the threshold for separation denoted byX_T. $X_T \epsilon \{X_0, X_1, X_2 \ldots\ldots\ldots X_{L-1}\}$.Based on the threshold the input image X are often rotten into sub-images into two sub-images[8].This methodology divides the image histogram into two separate parts as shown in Fig.1. In this method, the separation intensity is X_T conferred by the input mean brightness value, which is the average intensity of all pixels that construct the input image. When this separation method, these two histograms are severally equal. By doing this, the mean brightness of the resultant image can lie between the input mean and also the middle grey level [2].

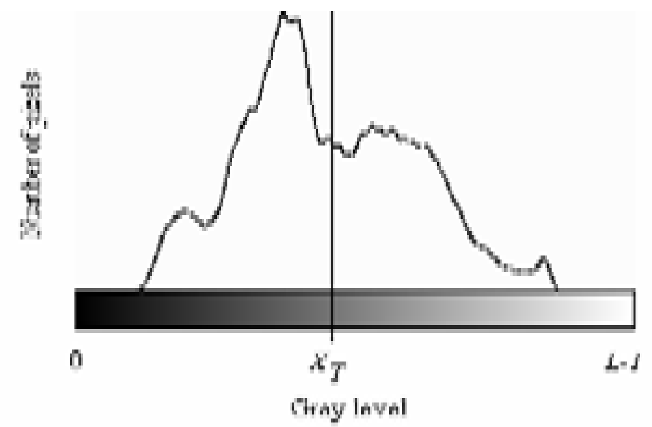

Fig-1: Bi-histogram equalization.

The histogram with range from 0 to *L*-1 is subdivided into two parts, with separating intensityX_T. This separation produces two sub histograms. The first histogram has the range of 0 to X_T, and the second histogram has the range of X_{T+1} to L-1.

4. DUALISTIC SUB-IMAGE HISTOGRAM EQUALIZATION (DSIHE)

Following the identical basic concepts employed by the BBHE technique of decomposing the original image into two sub-images and so equalize the histograms of the sub-images individually, [4] proposed the thus known as equal area dualistic sub-image HE (DSIHE) technique. Rather than decomposing the image supported on its mean grey level, the DSIHE technique decomposes the images aiming at the maximization of the Shannon's entropy [6] of the output image of decomposing the first image into two sub-images and so equalize the histograms of the sub-images individually. For such goal, the input image is decomposed into two sub-images, being one dark and one Bright, respecting the equal area property (i.e., the sub-images has the same amount of pixels) [4], it's shown that the brightness of the output image O created by the DSIHE technique is that the average of the equal area level of the image I and therefore the middle grey level of the image, i.e., L / 2. The authors of [4] claim that the brightness of the output image generated by the DSIHE technique does not present a significant shift in reference to the brightness of the input image, particularly for the large area of the image with the identical gray-levels (represented by little areas in histograms with nice concentration of grey levels), e.g., picture with little objects connecting to nice darker or brighter backgrounds.

5. MINIMUM MEAN BRIGHTNESS ERROR BI-HISTOGRAM EQUALIZATION (MMBEBHE)

Still following the fundamental principle of the BBHE and DSIHE methods of splitting a picture then applying the HE technique to equalize the ensuing sub-images severally proposed the minimum mean brightness error Bi-HE (MMBEBHE) technique [5]. The most distinctness between the BBHE and DSIHE ways and also the MMBEBHE one is that the latter searches for a threshold level l_t that splits the image I into two sub-images I $[0,l_t]$ and I $[l_t+1, L-1]$, specified the minimum brightness distinctness between the input image and also the output image is achieved, whereas the previous ways create solely the input image to perform the decomposition. Once the input image is decomposed by the threshold Level l_t, every of the two sub-images I $[0, l_t]$ and I $[l_t+1, L-1]$ has its histogram equal by the classical HE method, generating the output image. Assumptions and manipulations for finding the threshold level l_t in O (L) time complexity was made in [6]. Such strategy permits us to get the brightness l_m(O [O, l] ∪ O [l +1, L −1]) of the output image while not generating the output image for every candidate threshold level l, and its aim is to provide a technique appropriate for real-time applications [6].

6. RECURSIVE MEAN-SEPARATE HE METHOD (RMSHE)

Recall that the extensions of the HE method described so far in this section were characterized by decomposing the original image into two new sub-images. However, an extended version of the BBHE method named recursive mean separate HE (RMSHE), proposes the following. Instead of decomposing the image only once, the RMSHE method proposes to perform image decomposition recursively, up to a scale r, generating 2r sub-images. After, each one of these sub-images $I^r[l_f, l_s]$ is independently enhanced using the CHE method. Note that when r = 0 (no sub-images are generated) and r = 1, the RMSHE method is equivalent to the CHE and BBHE methods, respectively. In [5], they mathematically showed that the brightness of the output image is better preserved as r increases. Note that, computationally speaking, this method presents a drawback: the number of decomposed sub-histograms is a power of two.

7. RANGE LIMITED BI-HISTOGRAM EQUALIZATION (RLBHE)

RLBHE is formally outlined by the subsequent procedures:

1. Selecting a proper threshold for histogram separation.
2. Confirm the higher and therefore the lower bounds for histogram equalization.
3. Equalize every partition severally.

From the pattern recognition perspective, the best threshold ought to manufacture the simplest performance to separate the target class from the background class. This performance is characterized by intra-class variance. Otsu's methodology [7] is employed to automatically perform histogram form based mostly image threshold. The algorithm assumes that the image to be threshold contains two classes of pixels (e.g., foreground and background) then calculates the optimum threshold separating those two classes so that their intra-class variance is lowest.

The preservation of the mean brightness is of high demands in shopper natural philosophy. Though the brink threshold got by Otsu's technique will effectively separate the objects from the background, the mean brightness might not be strictly strained. Further measures should be taken to take care of the origin image brightness optimally. The result of (RLBHE) [8] shows that the planned algorithm rule has preserved the brightness well and provides the natural enhancement in most apart of the image [8].

Table-1: Comparison between deferent methods

Charact eristics	GHE	BPBH E	DSIB HE	MMB EBHE	RLBH E
Name	Glob al Histo gram Equal izatio n	Bright ness Preserv ing Bi-Histogr am Equali zation	Dual Sub Image Bi-Histogr am Equali zation	Minim um Mean Bright ness Error Bi-Histogr am Equali zation	Range Limite d Bi-Histogr am Equali zation

Method	Calculate cumulative distribution function.	Calculate Mean of image.	Calculate median of image.	Calculate minimum brightness difference between input image and output image.	Apply threshold selection method (Otsu's method).
Image Improvement	Good	Better than GHE	Very good than BBHE	More improved than DSIBHE	More brighter as original
Error (AMBE)	Absolute mean Brightness Error is Minimum up to some extent	Minimum than GHE	Minimum than BBHE	Minimum than DSIBHE	Minimum than MMBEBHE

8. CONCLUSION

We have presented the comparison of six Histogram Equalization techniques. The comparative study of Histogram Equalization based strategies shows that the contents that need higher brightness preservation and not holed well by HE, BBHE and DSIHE are suitably increased by RMSHE. MMBEBHE is that the extension of BBHE technique that gives more brightness preservation. Although these strategies will do sensible contrast enhancement, they conjointly cause a lot of annoying side effects looking on the variation of grey level distribution within the histogram [5]. RLBHE is advance method of MMBEBHE. Table shows the comparison between deferent contrast enhancement methods. In future work we will work with Range Limited Quad-Histogram for image contrast enhancement. This will produce definitely better result compare to the other techniques.

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BIOGRAPHIES

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