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 artifact 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.

Keywords— Image Contrast Enhancement, Histogram Equalization, Brightness Preserving Enhancement, Range Limit, Histogram Partition.

I. 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 it’s 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].

II. 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 histogram with range from 0 to $L-1$ is subdivided into two parts, with separating intensity $X_T$. This separation produces two sub histograms. The first histogram has the range of 0 to $X_T$, while the second histogram has the range of $X_T+1$ to $L-1$.

**IV. 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 grey-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.
V. Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE)

Still following the fundamental principle of the BBHE and DSIBHE 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 DSIBHE ways and also the MMBEBHE one is that the latter searches for a threshold level \( l \) that splits the image \( I \) into two sub-images \( I[[0, l]] \) and \( I[[l, +1, L -1]] \), 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 \( l \), every of the two sub-images \( I[[0, l]] \) and \( I[[l, +1, L -1]] \) has its histogram equal by the classical HE method, generating the output image. Assumptions and manipulations for finding the threshold level \( l \) in O (L) time complexity was made in [6]. Such strategy permits us to get the brightness \( B_{ML}(O[[0, l]] \cup O[[l +1, L -1]]) \) 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].

VI. Recursive Mean-Separate Histogram Equalization 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 \( 2^r \) sub-images. After, each one of these sub-images \( I'^{r}[l, j] \) 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.

VII. 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>
<thead>
<tr>
<th>Characteristics</th>
<th>GHE</th>
<th>BPBHE</th>
<th>DSIBHE</th>
<th>MMBEBHE</th>
<th>RLBHE</th>
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</thead>
<tbody>
<tr>
<td>Name</td>
<td>Global Histogram Equalization</td>
<td>Brightness Preserving Bi-Histogram Equalization</td>
<td>Dual Sub Image Bi-Histogram Equalization</td>
<td>Minimum Mean Brightness Error Bi-Histogram Equalization</td>
<td>Range Limited Bi-Histogram Equalization</td>
</tr>
<tr>
<td>Image Improvement</td>
<td>Good</td>
<td>Better than GHE</td>
<td>Very good than BBHE</td>
<td>More improved than DSIBHE</td>
<td>More brighter as original</td>
</tr>
<tr>
<td>Error (AMBE)</td>
<td>Absolute mean Brightness Error is Minimum up to some extent</td>
<td>Minimum than GHE</td>
<td>Minimum than BBHE</td>
<td>Minimum than DSIBHE</td>
<td>Minimum than MMBEBHE</td>
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VIII. CONCLUSION

We have presented the comparison of five 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. In future work we will work with range limited quad-histogram equalization for image contrast enhancement. Table shows the comparison. This will produce definitely better result compare to the other techniques.

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