A REVIEW ON HISTOGRAM EQUALIZATION TECHNIQUES FOR IMAGE ENHANCEMENT

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Abstract: Image enhancement is the simplest and most appealing area among all the digital image processing techniques. The main purpose of image enhancement is to increase contrast in a low contrast image. Image enhancement schemes are used for enhancement of images which includes gray scale manipulation, filtering and histogram equalization. Histogram equalization is one of the well known image enhancement technique. Histogram equalization becomes popular technique for contrast enhancement because this method is simple and effective. This paper represents review of some techniques in the area of image enhancement for brightness preservation because brightness preservation is highly demanded in consumer electronics field, when the image is effectively enhanced. Comparative analysis of different enhancement technique is done to illustrate the best possible technique which can be used as image enhancement. This comparison will be done on the basis of subjective and objective parameters. Subjective parameters are visual quality and computation time and object parameters are peak signal to noise (PSNR), Mean squared error (MSE), Normalized absolute error (NAE), Normalized correlation, Error color, Composite peak signal to noise ratio (CPSNR) and Absolute mean brightness error (AMBE).

Keywords: CLAHE, DHE, DSIHE, PSNR, AMBE.

I. INTRODUCTION

Digital image play very important role both in daily life applications such as satellite television, magnetic resonance imaging, computer tomography as well as in areas of research and technology such as in remote sensing, geographical information system (GIS) and astronomy [1]. Among all the five senses in humans, sight is most powerfully used to perceive their environment. Receiving and analyzing images forms a large part of the routine cerebral activity of human beings. In fact, more than 99% of the activity of the human brain is involved in processing images from the visual cortex. Confucius said "A picture is worth a thousand words" [2]. Image enhancement is simple and most appealing area among all the digital image processing techniques. The main purpose of Image enhancement is to bring out detail that is hidden in an image or to increase contrast in a low contrast image. In this paper a comparative study of different enhancement technique is done and comparison is done on the basis of objective parameters like PSNR, AMBE and contrast.

Image enhancement process consists of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine. Image enhancement can briefly defined as the process of improving the interpretability or perception of information in images for human viewers and providing better input for other automated image processing techniques. The principal objective of Image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. It is important to keep in mind that enhancement is a very subjective area of image processing. Improvement in quality of these degraded images can be achieved by using application of enhancement techniques.

A. Histogram Equalization (HE):

Histogram equalization is mainly used for contrast enhancement in a variety of applications due to its simple functions and effectiveness. In Histogram equalization we3 try to maximize the image contrast by applying a gray level transform which tries to flatten the resulting histogram. The flattening of Histogram and stretching the dynamic range of the gray levels is done by using cumulative density function of the image. The problem with Histogram equalization is that the brightness of an image is changed after the Histogram equalization, therefore it is not suitable for consumer electronic products where preserving the original brightness and enhancing contrast are important to avoid annoying artifacts.

B. Contrast Limited Adaptive Histogram Equalization (CLAHE) :

Contrast Limited Adaptive histogram equalization is an extension to traditional histogram equalization technique. It enhances the contrast of images by transforming the values in the intensity image I. It differs from ordinary Histogram equalization in respect that it operates on small data regions rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the specified histogram. The neighboring tiles are then combined using bilinear interpolation in order to eliminate artificially induced boundaries. The contrast, especially in homogeneous areas, can be limited in order to avoid amplifying the noise which might be present in the image.

C. Dualistic Sub-Image Histogram Equalization method (DSIHE) :

Dualistic sub-image histogram equalization method is a novel histogram equalization technique. In this technique the original image is decomposed into two equal area sub-images based on its gray level probability density function. Then the two sub-images are equalized respectively. At last, we get the result after the processed sub-images are composed into one image. In fact, the algorithm can not only enhance the image visual information effectively, but also constrain the original image's average luminance from great shift. This makes it possible to be utilized in video system directly.

D. Dynamic Histogram Equalization for image contrast enhancement (DHE) :

It employs a partitioning operation over the input histogram to chop it into some sub histograms so that they have no dominating component in them. Then each sub-histogram goes through Histogram equalization and is allowed to occupy a specified gray level range in the enhanced output image. Thus, a better overall contrast enhancement is gained by Dynamic Histogram Equalization with controlled dynamic range of gray levels and eliminating the possibility of the low histogram components being compressed that may cause some part of the image to have washed out appearance.

II. IMPLEMENTATION:

In this section we are comparing all the above defined techniques of histogram equalization on the basis of performance parameters in objective and subjective manner.

A. Contrast Limited Adaptive Histogram Equalization (CLAHE) :

Algorithm Steps:

1. Obtain all the inputs: Image, Number of regions in row and column directions, Number of bins for the histograms used in building image transform function (dynamic range), Clip limit for contrast limiting (normalized from 0 to 1)
2. Pre-process the inputs: Determine real clip limit from the normalized value if necessary, pad the image before splitting it into regions.
3. Process each contextual region (tile) thus producing gray level mappings: Extract a single image region, make a histogram for this region using the specified number of bins, clip the histogram using clip limit, and create a mapping (transformation function) for this region.
4. Interpolate gray level mappings in order to assemble final CLAHE image: Extract cluster of four neighboring mapping functions, process image region partly overlapping each of the mapping tiles, extract a single pixel, apply four mappings to that pixel, and interpolate between the results to obtain the output pixel; repeat over the entire image.

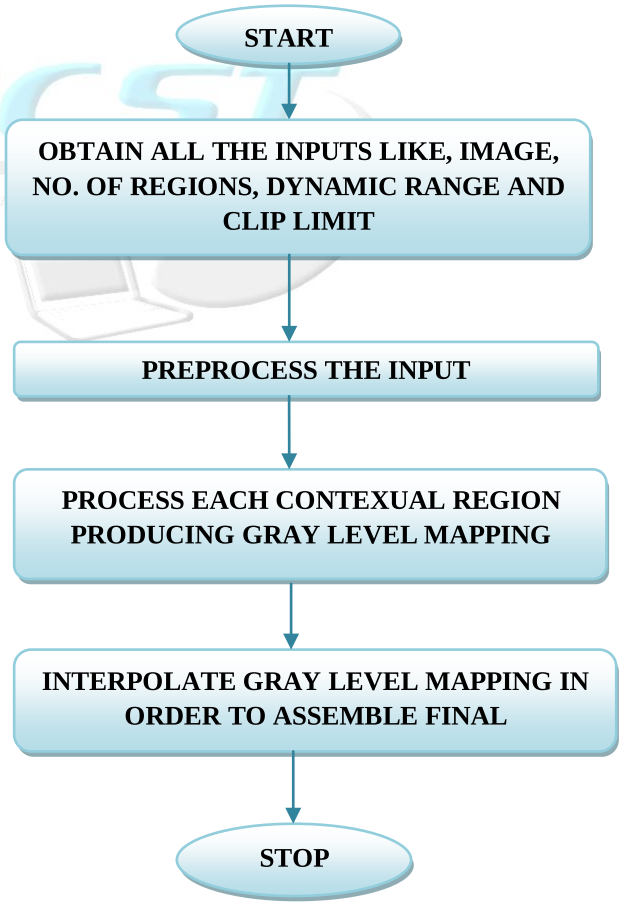

Figure 1: Flow chart for CLAHE.

B. Dualistic sub-image histogram equalization method (DSIHE) :

Algorithm Steps:

Suppose image X is segmented by a section with gray level of X=Xe and the two sub-images are X_L and X_U so we have

$X = X_L \cup X_U$ Here $X_L = (X(i,j)|X(i,j) < Xe, \forall X(i,j) \in X)$
$(X(i,j)|X(i,j) \geq Xe, \forall X(i,j) \in X)$ ……. (1)

It is obvious that sub image X_L is composed by gray level of {X0, X1 … Xe-1}, while sub image X_U is composed of {Xe, Xe+1,…………Xl-1}. The aggregation of the original images' gray level distribution probability is decomposed into {p0, p1... pe-1} and {pe, pe+1 ….pl-1} correspondingly. The corresponding cumulative distribution function will be

$C_L(X_K) = \frac{1}{p} \sum_{i=0}^{k} p^i$, K= 0, 1, ….., e-1 …. (2)

$C_U(X_K) = \frac{1}{(p-1)} \sum_{i=e}^{l-1} p^i$, K= e, e-1, e-2, ……, L-1

Based on the cumulative distribution function, the transform functions of the two sub images' histogram are equalized below.

$F_L(X_K) = X_0 + (X_{e-1} - X_0)\, c(X_K)$, k = 0 ,1, … . e – 1

$F_U(X_K) = X_e + (X_{L-1} - X_e)\, c(X_K)$, k=e,e+1,………..L-1… (3)

At last result of dualistic sub image histogram is obtained after the two equalized sub images are composed into one image. Suppose Y denotes the processed image then

$Y=\{Y(i,j)\}= F_L(X_L) \cup F_U(X_U)$ ……. (4)

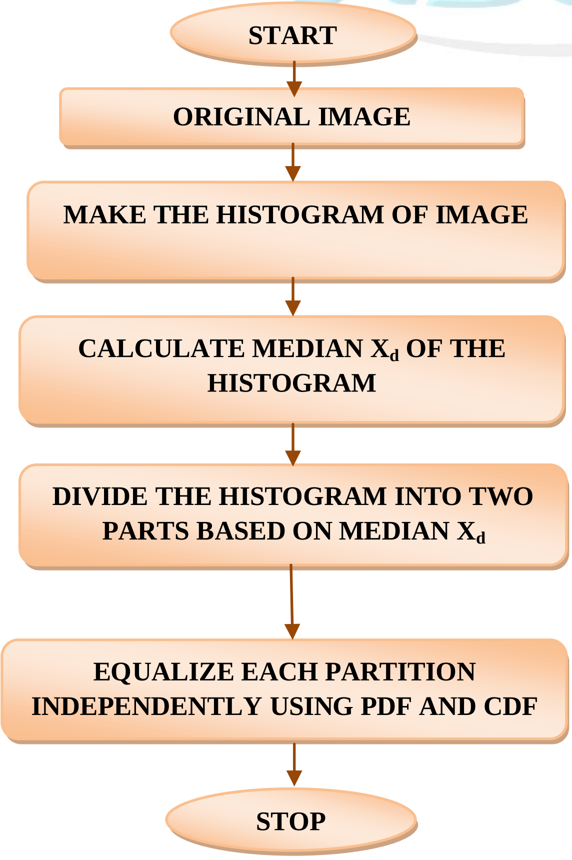

Figure 2: Flow Chart for DSIHE.

C. Dynamic histogram equalization for image contrast enhancement (DHE) :

Algorithm Steps:

1. Histogram Partition: DHE partitions the histogram based on local minima. At first, it applies a one-dimensional smoothing filter of size 1 x 3 on the histogram to get rid of insignificant minima. Then it makes partitions (sub-histograms) taking the portion of histogram that falls between two local minima (the first and the last non-zero histogram components are considered as minima). Mathematically, if m_0, m_1, …, m_n are (n+1) gray levels (GL) that correspond to (n+1) local minima in the image histogram, then the first sub-histogram will take the histogram components of the GL range $[m_0, m_1]$, the second one will take $[m_1+1, m_2]$ and so on. These histogram partitioning helps to prevent some parts of the histogram from being dominated by others.

2. Gray Scale Allocation: For each sub-histogram, DHE allocates a particular range of GLs over which it may span in output image histogram. This is decided mainly based on the ratio of the span of gray levels that the sub-histograms occupy in the input image histogram.

Here the straightforward approach is:

$Spain_i = m_i - m_{i-1}$

$Range_i = \frac{spain_i}{\sum span_i} * (L-1)$

Where,

$spain_i$ = dynamic GL range used by sub-histogram i in input image.

m_i = i^{th} local minima in the input image histogram.

$range_i$ = dynamic gray level range for sub-histogram i in output image.

The order of gray levels allocated for the sub-histograms in output image histogram are maintained in the same order as they are in the input image, i.e., if sub-histogram i is allocated the gray levels from $[i_{start}, i_{end}]$, then $i_{star}t = (i-1)_{end} + 1$ and $i_{end} = i_{start} + range_i$. For the first sub-histogram, j, j_{start} = r0.

3. Histogram Equalization: Conventional HE is applied to each sub-histogram, but its span in the output image histogram is allowed to confine within the allocated GL range that is designated to it. Therefore, any portion of the input image histogram is not allowed to dominate in Histogram Equalization. Flow chart for DHE is given in figure 3.

III. COMPARATIVE PARAMETERS

Comparison can be done on basis of subjective parameters and objective parameters. In this paper we are dealing with comparison of objective parameter which will include peak signal to noise ratio (PSNR), Absolute mean brightness error (AMBE) and contrast.

A. Peak-signal-to-noise-ratio (PSNR):

PSNR is the evaluation standard of the reconstructed image quality, and is important measurement feature. PSNR is measured in decibels (dB) and is given by:

$$\text{PSNR} = 10 \log \left(\frac{255^2}{MSE}\right)$$

Where the value 255 is maximum possible value that can be attained by the image signal. Mean square error (MSE) is defined as Where M*N is the size of the original image. Higher the PSNR value is, better the reconstructed image is.

B. Absolute mean brightness error (AMBE):

It is the Difference between original and enhanced image and is given as:

$$\text{AMBE} = |E(x) - E(y)|$$

Where E(x) = average intensity of input image E(y) = average intensity of enhanced image.

C. Contrast:

Contrast defines the difference between lowest and highest intensity level. Higher the value of contrast means more difference between lowest and highest intensity level.

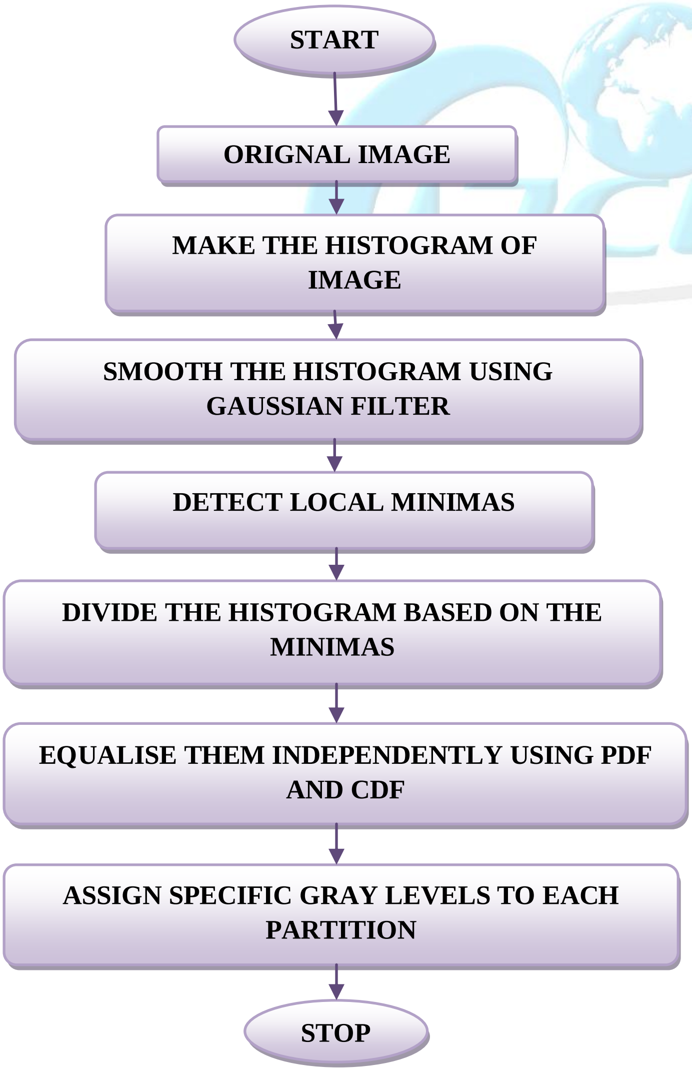

Figure 3: Flow Chart for DHE.

IV. TOOL TO BE USED

For comparison and implementation of different histogram technique for image enhancement MATLAB 7.0.2 version is used. In that image processing toolbox is used. MATLAB® is a high-performance language for technical computing.

V. RESULT AND DISCUSSION

To verify the various proposed methods of histogram equalization we are using image of "Rice" as shown in fig .4(a). After applying the three different image enhancements technique the obtained results are shown in fig.4 (b to d). After the comparison the graphical representation has also been done for a quick analysis of results as shown in fig.5. All the techniques have been tested for all the assumed standard test images. The performances of these techniques are evaluated in terms of PSNR, AMBE and contrast which is shown in table 1.

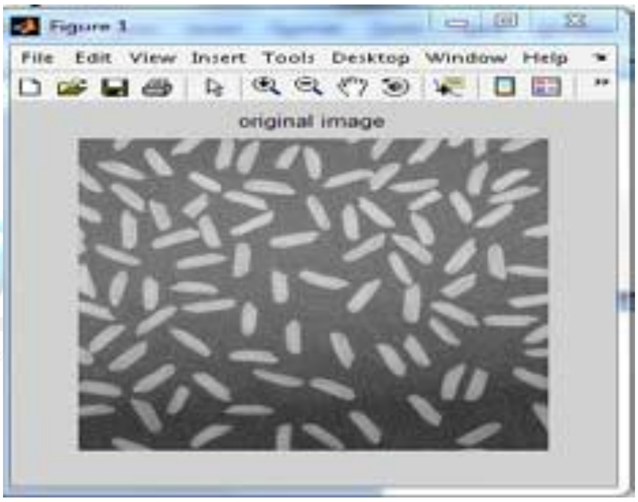

Figure 4(a) : Original Image

Figure 4(b): CLAHE Image

Figure 4(c): DSIHE Image

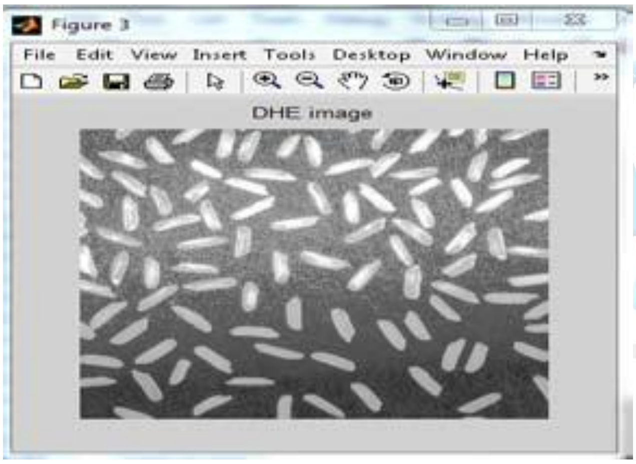

Figure 4(d): DHE Image

Figure 4. Enhanced Result of real image of "Rice" is as shown in image a, b, c, d.

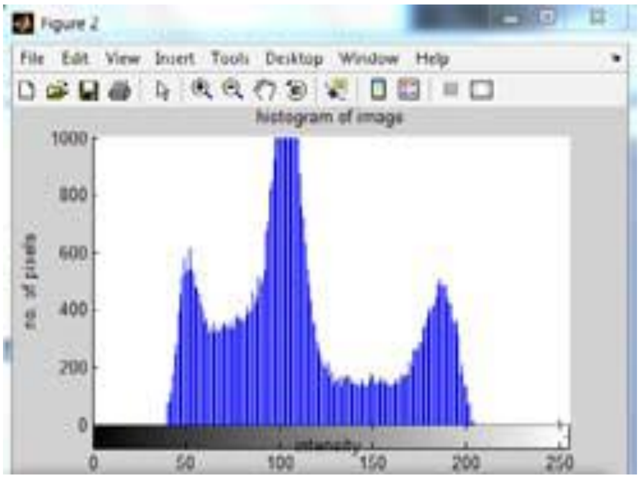

Figure 5(a): Histogram of original image

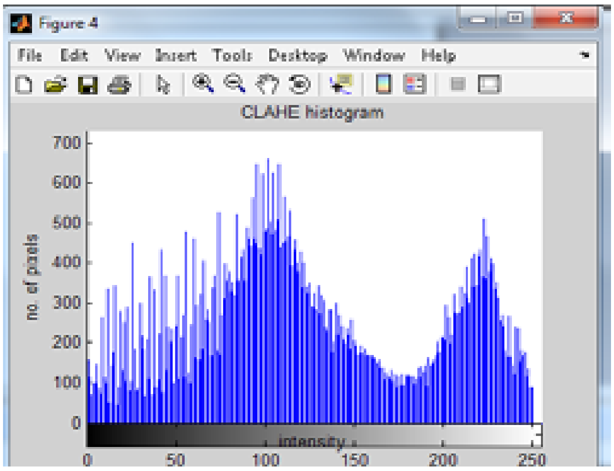

Figure 5 (b): CLAHE Histogram

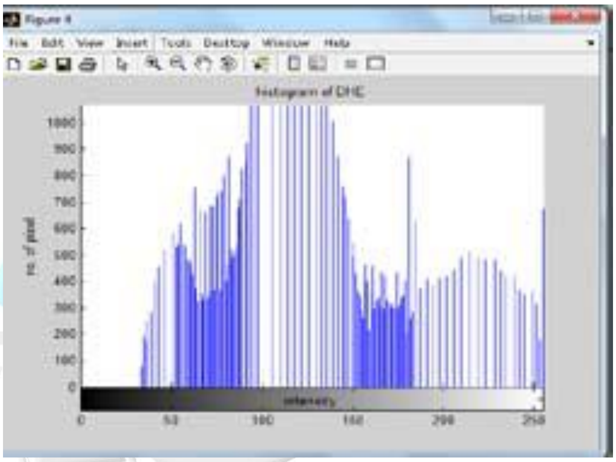

Figure 5 (c): DSIHE Histogram

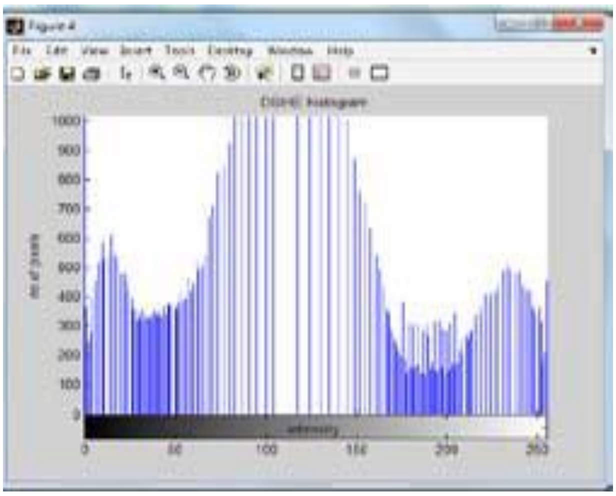

Figure 5 (d): DHE Histogram

Figure 5: Equalized Histograms for Image "Rice" as shown in image a, b, c, d as original, CLAHE, DSIHE, DHE Respectively.

Table 1: Comparison of Various Parameters for "Rice" Image

Parameter technique	AMBE	Contrast	PSNR
CLAHE	13.8521	23.5878	0.0366
DSIHE	4.9081	33.8767	0.0327
DHE	13.0886	12.1438	0.1107

Anyone can make comparison of parameter AMBE (Absolute mean brightness error) for different image enhancement techniques. The value of AMBE should be as small as possible which indicates that difference between original and enhanced image should be minimum. Therefore in terms of AMBE, DSIHE technique gives best results as AMBE is taken in negative. Now considering PSNR, CLAHE gives better output as it is cleared from the formula that PSNR should be as high as possible so that noise content should be lower than signal content.

VI. CONCLUSION

In this paper, a frame work for image enhancement based on prior knowledge on the Histogram Equalization has been presented. Many image enhancement schemes like Contrast limited Adaptive Histogram Equalization (CLAHE), Equal area dualistic sub-image histogram equalization (DSIHE), Dynamic Histogram equalization (DHE) algorithms has been implemented and compared. From the experimental results, it is found that all the three techniques yields Different aspects for different parameters.

In future, for the enhancement purpose more images can be taken from the different application fields so that it becomes clearer that for which application which particular technique is better for Gray Scale Images. Optimization of various enhancement techniques can be done to reduce computational complexity as much as possible.

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