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COMPARATIVE ANALYSIS FOR CONTRAST ENHANCEMENT USING HISTOGRAM EQUALIZATION TECHNIQUES

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Abstract: Contrast enhancement is basically improving the quality of images for better perception. They are widely used for image and video processing to achieve wider dynamic range. There are two major goals: contrast enhancement and preserving the brightness of the image. This paper presents the parameters comparison and simulation results of various histogram equalization techniques like GHE, BBHE, Novel, BPDHE in terms of Correlation, Peak Signal to Noise Ratio (PSNR), Normalized Absolute Error (NAE) due to which visual quality of the image becomes better.

Keywords: Histogram Equalization, Contrast Enhancement, GHE, BBHE, BPDHE, Novel

INTRODUCTION

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. It flattens and stretches the dynamic range of the image's histogram and resulting in overall contrast enhancement. Due to flattening property of HE, either it performs over or under enhancement. To avoid this problem, Kim in 1997 proposed Bi-level histogram equalization which preserves the mean brightness of a given image. In this algorithm, BBHE firstly divide an input image into two sub-images based on the mean of the input image. One of the sub-images is the set of samples less than or equal to the mean whereas the other one is the set of samples greater than the mean. Then the BBHE equalizes the sub-images independently based on their respective histogram which has an effect of preserving mean brightness [1].

Next, the mean brightness preserving histogram equalization (MBPHE) methods basically can be divided into two main groups, which are bisections MBPHE, and multi-sections MBPHE. Bisections MBPHE group is simplest group of MBPHE. Fundamentally, these methods are separate the histogram of two sections. These two histogram sections are then equalized independently. The major difference among the methods in this family is the criteria used to divide the input histogram [2]. Next, Dynamic Histogram equalization (DHE) technique, control over the effect of traditional HE so that it performs the enhancement of an image without making any loss of details in it. DHE partitions the image histogram based on local minima and assigns specific gray level ranges for each partition before equalizing them separately. These partitions further go through a repartitioning test to ensure the absence of any dominating portions.

This method outperforms other present approaches by enhancing the contrast well without introducing severe side effects such as washed out appearance or undesired artefacts [3]. The brightness preserving dynamic histogram equalization (BPDHE) is actually an extension to both MPHEBP and DHE. Similar to MPHEBP, the method partitions the histogram based on the local maximums of the smoothed histogram. However, before the histogram equalization taking place, similar to DHE. As the change in the dynamic range will cause the change in mean brightness, the final step of this method involves the normalization of the output intensity. So it can produce the output image with the mean intensity almost equal to the mean intensity of the input, thus BPDHE will produce better enhancement and fulfil the requirement of maintaining the mean brightness of the image [4].

In Novel method, Firstly applies some pre-processing steps on the histogram corresponding to the image and then applies histogram equalization [5].

PARAMETERS MEASURED

In order to test the proposed method, Simulation using Matlab7.10 are performed on input image. To evaluate the image enhancement performance, Peak Signal to Noise Ratio (PSNR), Normalized absolute error (NAE) and Correlation used as the criterion.

(a) Correlation:- Correlation estimates the similarity of the structure of two images.

$$Correlation = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j)]^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}f'(i,j)^2} \quad (1)$$

(b) PSNR:-Peak signal to noise ratio
PSNR is a measure of the peak error. A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR.

$$PSNR = 10\log(255^2/\mathrm{MSE}) \quad (2)$$

(c) NAE:-Normalized absolute error
NAE is a measure of how far is the enhanced image from the original image with the value of zero being the perfect fit. The value of Normalized Absolute Error (NAE) is more, so it means that image is poor.

$$NAE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}((s(i,j)-\hat{s}(i,j))^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}((s(i,j))^2} \quad (3)$$

GLOBAL HISTOGRAM EQUALIZATION (GHE)

Let input image f(x, y) composed of discrete gray levels in the dynamic range of [0, L-1]. Cumulative density function is defined as

$$C(r_k) = \sum_{i=0}^{k} P(r_i) = \sum_{i=0}^{k} \frac{n_i}{n} \quad (4)$$

where $P(r_i)$ is probability density function; n represents total number of pixels in the input image; n_i represents number of pixels having gray level r_i .

Hence $C(r_k)$ can easily be mapped to the dynamic range of [0, L-1] multiplying it by (L-1). So Output level is

$$H = (L-1) \times C(r_k) \quad (5)$$

The output level is incremented by

$$\Delta H = (L-1) \times P(r_i) \quad (6)$$

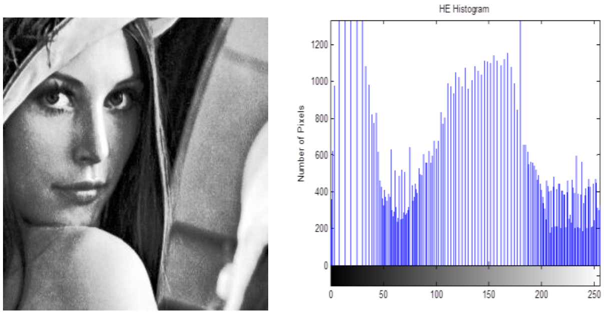

Figure.1.Resultant GHE image and its histogram

BRIGHTNESS PRESEVING BI-HISTOGRAM EQUALIZATION (BBHE)

BBHE divides an input image into two subimages (X_L and X_U) based on the mean of the input image.

$$X = X_L \bigcup X_U \quad (7)$$

$$X_L = \{X(i,j) | X(i,j) \leq X_m, \forall X(i,j) \in X\} \quad (8)$$

$$X_U = \{X(i,j) | X(i,j) > X_m, \forall X(i,j) \in X\} \quad (9)$$

The respective cumulative density functions for X_L and X_U are defined as

$$C_L(x) = \sum_{j=0}^{k} P_L(X_j) \quad (10)$$

$$C_U(x) = \sum_{j=m+1}^{k} P_U(X_j) \quad (11)$$

Where P_L and P_U are probability density function of respective subimages X_L and X_U.

The following transfer functions are

$$f_L(x) = X_0 + (X_m - X_0) C_L(x) \quad (12)$$

$$f_U(x) = X_{m+1} + (X_{L-1} - X_{m+1}) C_U(x) \quad (13)$$

The subimages are equalized independently .Hence, the input image X is equalized over the entire dynamic range (X_0 , X_m) and (X_{m+1} , L-1).

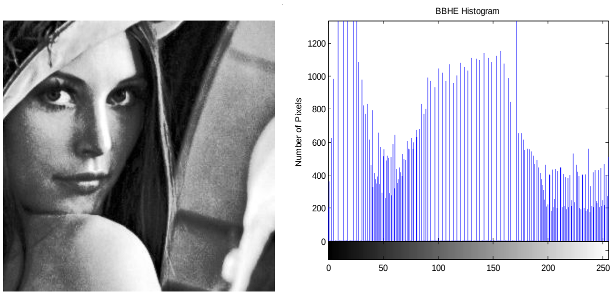

Figure.2.Resultant BBHE image and its histogram

NOVEL

The probability density function of the original image is changed by following equation

$$P_{new} = \begin{cases} P_{max} & P(K) = P_{max} \\ \left(\frac{P(K)}{P_{max}}\right)^r \times P_{max} & 0 < P(K) < P_{max} \\ 0 & P(K) = 0 \end{cases} \quad (14)$$

where P_{max} is the highest value in PDF of the original image. The value of r is to control the degree of enhancement. This method is spread the histogram components uniformly over the grayscales and preventing histogram components from concentrating particular locations on the gray especially in low gray level. The remaining steps are same as histogram equalization.

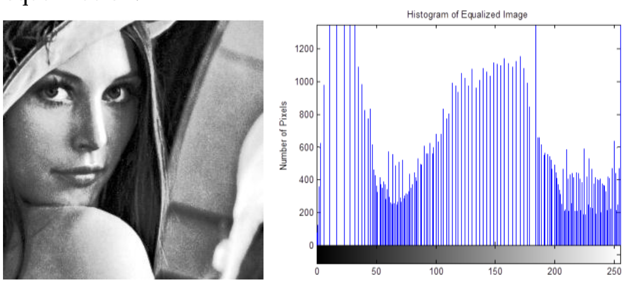

Figure.3.Resultant Novel image and its histogram

BRIGHTNESS PRESERVING DYNAMIC HISTOGRAM EQUALIZATION (BPDHE)

BPDHE can produce the output image with the mean intensity almost equal to the mean intensity of the input image. Firstly, the histogram is smoothed by using one dimensional Gaussian filter.

$$G(x) = e^{-(x^2/2\sigma^2)} \quad (15)$$

The smoothed histogram is divided into sub histograms based on its local maximums. Then, each partition will be assigned a new dynamic range by

$$span_i = high_i - low_i \quad (16)$$

$$factor_i = span_i \times \log_{10} M \quad (17)$$

$$range_i = (L-1) \times factor_i \Big/ \sum_{k=1}^{n+1} factor_k \quad (18)$$

where $high_i$ is the highest intensity value contained in the sub histogram ; low_i is the lowest intensity value; M is total pixels.

Each partition is equalized independently. The transfer function

$$y(x) = start_i + (end_i - start_i) \sum_{k=start_i}^{x} \frac{n_k}{M} \quad (19)$$

When we applied the brightness normalization, then the mean brightness of output is shifted. So the mean output intensity will be almost equal to the mean input intensity. The transform function of brightness normalization is defined by

$$g(x, y) = (M_i / M_0) f(x, y) \quad (20)$$

where g(x, y) is the final output image and f(x, y) is the output just after the equalization.

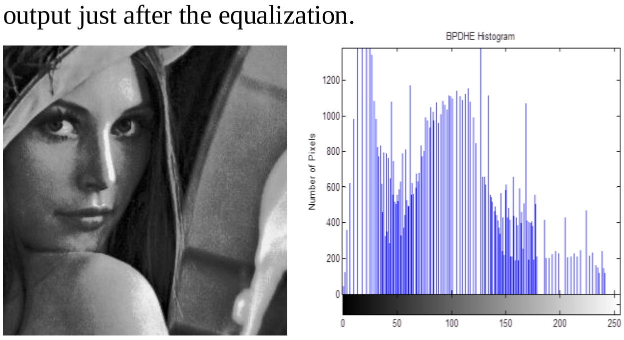

Figure.4. Resultant BPDHE image and its histogram

SIMULATION RESULTS AND DISCUSSION

From the results shown in Table 1, it is analysed that PSNR of BPDHE is higher than other techniques. So, the quality of image is good. In BPDHE method, it is observed that NAE and correlation have the value of 0.1020 and 1.0078 which are lower than others. So the quality of image is better. Hence, the overall performance of BPDHE is better than other techniques.

Table 1: Image parameters of different HE

Methods	Parameters		
	Correlation	PSNR	NAE
GHE	1.3696	15.6313	0.3719
BBHE	1.2940	16.9928	0.2886
Novel	1.3898	15.2126	0.3955
BPDHE	1.0078	27.2010	0.1020

CONCLUSION

It is concluded from the paper that BPDHE has better contrast enhancement than other techniques without introducing unwanted artifacts, while at the same time maintain the input brightness. The histogram equalization techniques are compared on the basis of Correlation, PSNR and NAE parameters. In future, more histogram techniques can be analyzed for the improvement of PSNR, Correlation and NAE.

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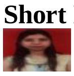
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