IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 3, Issue 2, Feb 2015, 65-76

REVIEW OF HISTOGRAM BASED IMAGE CONTRAST ENHANCEMENT TECHNIQUES

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ABSTRACT

Image enhancement is a technique performed on a digital image in order to make it more appropriate for various applications. It is used to improve the visualization and the clarity of image or to make the original image more appropriate for computer processing. By contrast enhancement we change the intensity of pixels of an image to make it more useful for computer processing. We study and review the different image contrast enhancement techniques because during enhancing the contrast we losses the brightness of image. By considering this fact, the mixture of global and local contrast enhancement techniques may enhance the contrast of image with preserving its brightness. There are many image contrast enhancement techniques such as HE, BBHE, DSIHE, MHE, MMBEBHE, RMSHE, GHE LHE and IDBPHE. This paper focuses on the comparative study of contrast enhancement techniques with special reference to HE, MHE & IDBPHE techniques. These novel method will be used in many fields, such as medical image analysis, image processing, industrial X-ray image processing, microscopic imaging etc.

KEYWORDS: Image Enhancement, Histogram Equalization, Contrast Enhancement

I. INTRODUCTION

Image enhancement process consists of a collection of various techniques which improve the appearance of an image or make a better image for human or computer processing. Image enhancement means as the improvement of an image appearance by increasing or reducing some features with improving the distance between pixels. The objective of enhancement is to process an image so that the resultant image is more suitable for processing than the original image. Image enhancement is one of the most important and interesting area where we visually feel the changes of an image. Image enhancement is having the following subcategories: spatial domain methods and frequency domain methods. In spatial domain method operations we perform are based on direct operation on pixels of an image whereas in frequency domain methods are based on adapting the Fourier transform of an image. Image enhancement perform the prime and special role in many application of image processing, such as medical image analysis, industrial X-ray image processing, microscopic imaging etc. It mainly improve the visual appearance of the image or to make the original image more suitable for human or computer processing [1]. Generally, an image may have poor quality due to the poor quality of the imaging instruments or devices or distortion or the adverse external conditions at the time of image capturing or image acquisition.

The contrast enhancement is one of the commonly used image enhancement methods to improve the contrast with preserving the brightness. Now days we are having many methods for image contrast enhancement have been proposed which can be broadly categorized into two categories: direct methods and indirect methods. Among the indirect methods, the histogram equalization (HE) techniques have been widely used because of its simplicity and effectiveness as well as the simplicity to understand and implementation. The fundamental principle of HE is to make the histogram of the enhanced image approximate to a uniform distribution of image pixels so the contrast of the image improve. Contrast enhancement changing the pixels intensity of the input image. Contrast enhancement is based on five techniques such as local, global, partial, bright and dark contrast. This paper is organized as follows: Section II describes the different contrast enhancement techniques. Section III describes the result and discussion. Section IV concludes the paper.

II. METHODOLOGY

Histogram based image contrast enhancement techniques are:

A. Histogram Equalization (HE)

Histogram equalization [2] is widely used technique for contrast enhancement in a variety of applications due to its simple function and effectiveness. It works by flattening the histogram and stretching the dynamic range of the gray levels by using the cumulative density function of the image. One problem of the histogram equalization is that the brightness of an image is changed after the histogram equalization, hence not suitable for consumer electronic products, where preserving the original brightness and enhancing contrast are essential to avoid artifacts or removing the noise.

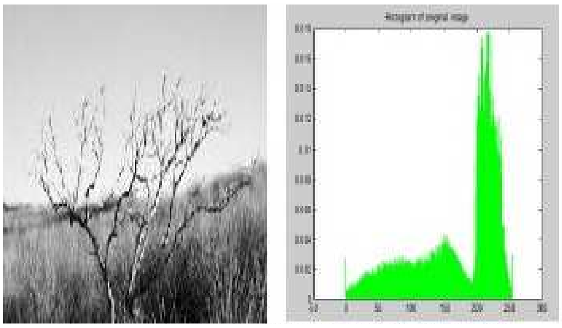


Figure 1(a): Original Gray Scal Image and it's Histogram

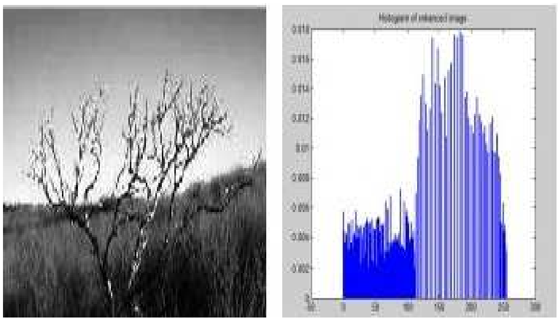


Figure 1(b): Result of HE and it's Histogram

Above Figure 1(a) shows the original image and it’s histogram and Figure 1(b) shows the image after performing Histogram. HE has an effect of stretching the dynamic range of a given histogram since HE improves the pixel density or pixel distribution of the image [3].

B. Brightness Bi-Histogram Equalization (BBHE)

In order to overcome the drawback introduced by the HE method described in the previous subsection, a brightness preserving Bi-HE (BBHE) [4] method was proposed. Figure 2(a) shows the original image before apply the

BBHE method. On this image we apply BBHE method is used to decompose the original image into two sub-images, by using the image mean gray-level, and then apply the HE method on each of the sub-images. Figure 2(b) Bi – histogram equalization. The BBHE method produces an output image with the value of brightness (mean gray-level) located in the middle of the mean of the input image. The BBHE technique is a hybrid method between mean brightness preserving histogram equalization method. This technique preserves the brightness and also improves the local contrast. This method uses the neighborhood matrix to improve the pixel distance. This technique can enhance the images without producing unnecessary artifacts [5] which was introduced by HE method.

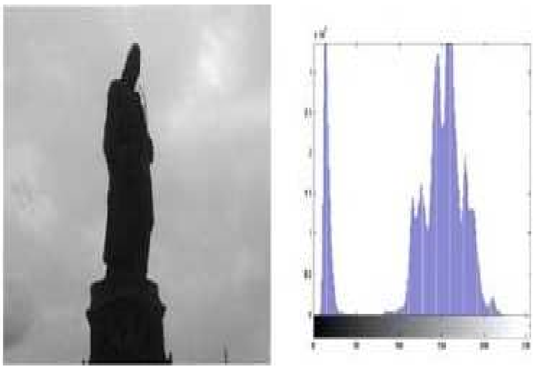


Figure 2(a): Original Gray Scal Image and it's Histogram

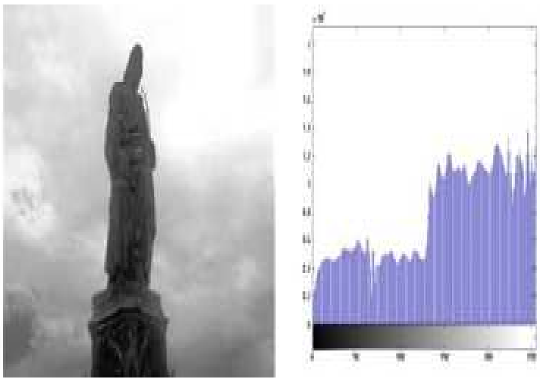


Figure 2(b): Result of BBHE and it's Histogram

C. Dualistic Sub Image Histogram Equalization (DSIHE)

Dualistic sub-image histogram equalization (DSIHE) [6] also separates the input histogram into two subsections. Both BBHE and DSIHE are similar except that DSIHE chooses to separate the histogram based on gray level with cumulative probability density equal to 0.5 instead of the mean as in BBHE, i.e. instead of decomposing the image based on its mean gray level. Equal area dualistic sub-image Histogram Equalization method follows the same basic idea of BBHE method. It decomposes the original gray scale image into two sub-images and then equalizes the histograms of the sub-images separately [7] instead of decomposing the image based on its mean gray level. The input image is decomposed into two sub-images, out of them one dark and one bright, respecting the equal area property (i.e., the sub-images has the same amount of pixels).

It is shown that the brightness of the output image produced by the DSIHE method is the average of the equal area level of the image I and the middle gray level of the image, i.e., L / 2. Figure 3 shows an original image and it’s histogram after applying BBHE and DSIHE. The authors claim that the brightness of the output image generated by the DSIHE method.

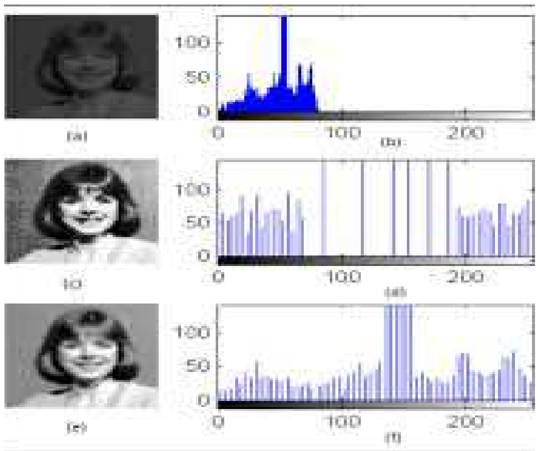


Figure 3: Original Image and it's Histogram after BBHE and DSIHE

This method does not change the brightness of the output image. Images with large object or small object have the same brightness which is approximately equal to the original image. Small and large object doesn't affect the brightness of output image, it is preserved before and after the contrast enhancement. The result of the dualistic sub-image histogram equalization is obtained after the two equalized sub images are composed into one image [5].

D. Multi Histogram Equalization (MHE)

In this technique, we sub-divide the image into multiple sub-images, same as in the image contrast enhancement provided by the HE. Each image is less powerful to provide the output image to have a more natural appearance. The concept of these methods arises two basic questions. The first question is (i) how to sub-divide the input image. The image decomposition process is based on the histogram of the image. The histogram is divided into different classes, these classes are determined by the threshold levels, where each histogram class represents a sub-image. The decomposition process is somewhere looks as an image segmentation process executed through multi-threshold selection. (ii) The second question is how many sub-images we can create form the original image after decomposition. This number depends on the process of image decomposition, and so this question is directly linked with the first question of how to sub-divide the image[8].

MHE technique consists of three steps:

- Multi histogram decomposition.
- Finding the optimal thresholds.
- Automatic thresholding criterion.

Figure 4(a): Original Image of Lady

Figure 4 (b): Image of Lady after MHE

Above figure 4(a) is an image of a lady and figure 4(b) represent the performance of the MHE method result which shows that the contrast is enhance with preserving the brightness. In this method the author proposed and tested a new framework called MHE for image contrast enhancement and brightness preserving which generated natural looking images. The experiments showed that MHE methods is better on preserving the brightness of the processed image (in relation to the original one) and yields images with natural appearance, with the improvement of contrast and preserving the brightness.

E. Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE)

Minimum mean brightness error Bi-HE (MMBEBHE)[9] method follow the same basic principle of the BBHE and DSIHE methods of decomposing an image and then applying the Classical Histogram Equalization (CHE) method to equalize the resulting sub-images independently[10]. The main difference between the BBHE and DSIHE methods and the MMBEBHE one is that for the threshold value on which the decomposition is dependent we search later latter, whereas the former methods consider only the input image to perform the decomposition. At the first stage the input image is decomposed by the threshold level, each of the two sub-images has its histogram equalized by the classical HE process, and after that generating the output image. Assumptions and manipulations for finding the threshold level in this method is somewhere time consuming which increase the time complexity. Such strategy allows us to obtain the brightness of the output image without generating the output image for each candidate threshold level, and its aim is to produce a method suitable for real-time applications. Figure 5(a) shows the original image of U2 and figure 5(b) shows the resultant image after apply MMBEBHE.

MMBEBHE technique consists of three steps:

- Calculate the AMBE for each of the threshold level.
- Find the threshold level, XT that yield minimum MBE.
- Separate the input histogram into two based on the XT found in step 2 and equalized them independently as in BBHE.

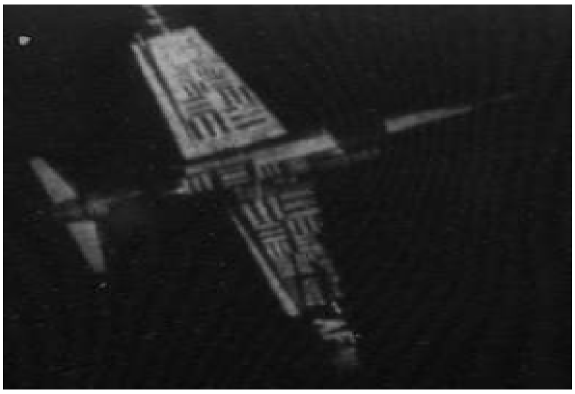


Figure 5(a): Original Image of U2

F. Global Transformation Histogram Equalization (GHE)

The global transformation function rearrange the intensity values of the image in such a way that it stretches the dynamic range of the image histogram which result a better contrast enhancement image. The Recursive Mean Separate Histogram Equalization (RMSHE) is used as a generalization of both GHE [11] and BBHE that allows scalable brightness preservation. The main idea is to divide the input histogram into two sub-parts based on the mean of the input histogram. After mean partitioning, the resulting sub histogram again sub-divided into more sub-histogram based on the value of recursion r.

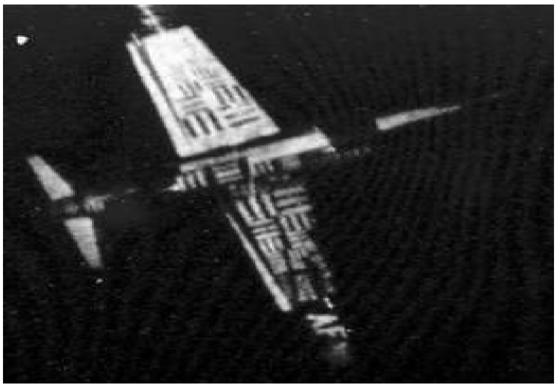
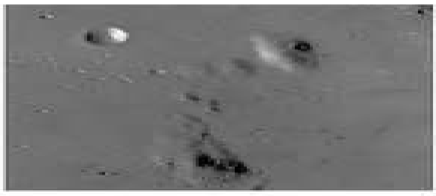


Figure 5(b) : Image after Performing MMBEBHE

The resulting 2r histogram regions are equalized independently [14]. Brightness level adjustment is provided by the level of recursion.



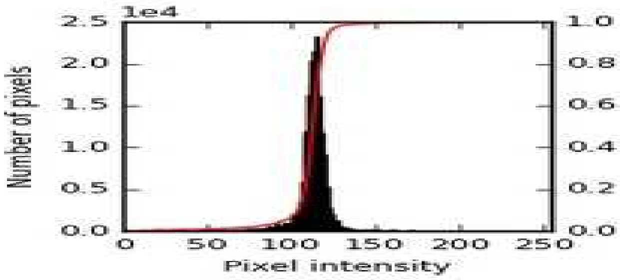


Figure 6(a):Low Contrast Image with it's Pixel Intensity

G. Local Transformation Histogram Equalization (LHE)

In GHE method we consider the global information and cannot consider the local light condition or local conditions. Local Histogram Equalization (LHE) performs block-overlapped histogram equalization. LHE defines a sub-block and retrieves its histogram information then histogram equalization is useful for the center pixel using the Cumulative Density Function (CDF) of that sub block. After that, the sub block is moved by one pixel and sub block histogram equalization is repeated until the end of the input image is reached. Though LHE cannot adjust to partial light information, still it over-enhances some portions depending on its mask size. However, selection of an optimal block size that enhances all part of an image is not an easy task to perform. The intensity pair distribution based method exploits the neighborhood information of all pixels to generate a global intensity mapping function.

In general, digital images contain a 2D array of intensity values, with locally varying Histogram Weighting Histogram Segmentation Histogram Equalization information that results from a different combination of unexpected features such as edges and uniform regions. Since different parts of the image have different statistical characteristics, apply the same approach block wise to handle local information more effectively. Within each block, generate the set of intensity pairs from a pixel’s 8-connected neighbors. In a real 2D image, many edge-pairs exist near the edges. Therefore, accumulate all the expansion forces between the edge pairs. Now the smooth intensity pairs may lie within the intensity range of the edge pairs. Due to the contrast stretch, the smooth region’s intensity will also be stretched. To avoid such circumstances, opposed to expansion forces are generated within the intensity range of the smooth intensity pairs. Similarly, all the opposed to expansion forces are accumulated for those intensity pairs of the smooth region, and then subtracted from the expansion forces with a certain impact factor w to obtain the net expansion force.

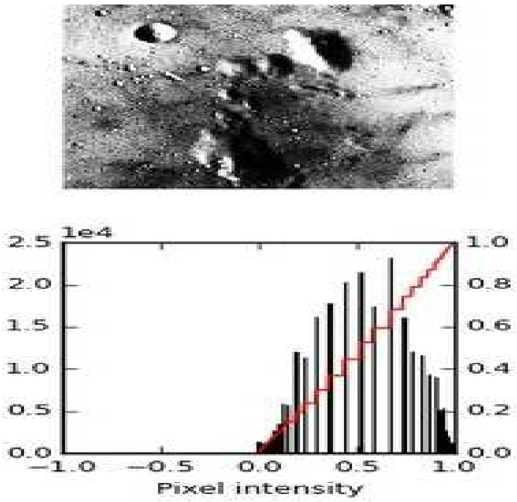


Figure 6(b): Image after GHE

H. Recursive Mean Separate Histogram Equalization (RMSHE):

In Histogram Equalization based method Brightness preservation can be achieved by having mean separation before performing the Histogram equalization process as in BBHE. Mean-separation refers to separating the image into two sub-image based on the mean of the input image. Mean-separation means to separate an image based on the mean of input image [7].

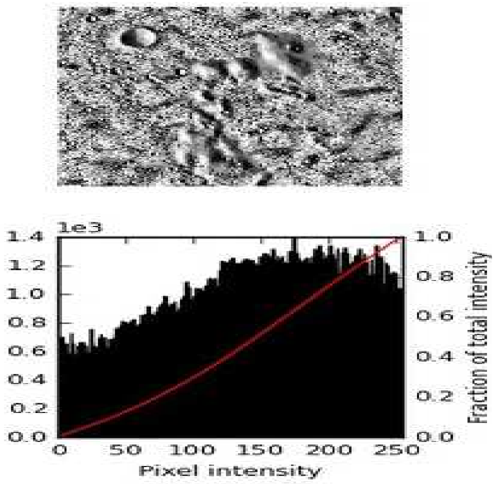


Figure 6(c): Image After LHE

However, RMSHE technique [12] is an extension of BBHE (where mean-separation was done only once). In fact, this is equivalent to separate the histogram into two based on the mean of the input image's histogram. After me an separation, the resulting new histograms are equalized independently. In RMSHE, instead of decomposing the input image only once, it is decomposed recursively up to a recursion level r, therefore 2r sub images will be generated. Each sub-image is then equalized independently with histogram equalization method. If r=0, that means no sub-image decomposition is done, i.e. it is equivalent to HE method only [1] [10]. When one mean separation is done before equalization, i.e. r=1, this is equivalent to BBHE. This increases a level of brightness preservation. Similarly, two mean-separations before equalization will result in much higher level of brightness preservation as compared to r=0 and r=1 levels. In typical HE, no mean-separation is performed and thus, no brightness preservation. In BBHE, the mean-separation is done once and thus, achieve certain extends of brightness preservation. In cases where more brightness preservation is required. This method proposed to perform the mean separation recursively; separate the resulting histograms again based on their respective means. Recursive Mean- Separate Histogram Equalization (RMSHE) is basically a generalization of HE and BBHE in the aspect of brightness preservation. This idea is illustrated more clearly in the following figures. It will be shown that more mean-separation recursively will result in more brightness preservation.

Figure 7(a): Original Image of a Jet-Plan

Figure 7(b): Image of Jet Plan after RMSHE

To perform the separation recursively separate each new histogram further based on their respective mean. It is analyzed mathematically that the output image's mean brightness will converge to the input image's mean brightness as the number of recursive mean separation increases. Besides, the recursive nature of RMSHE also allows scalable brightness preservation, which is very useful in consumer electronics.

L. Image Dependent Brightness Preserving Histogram Equalization (IDBPHE)[20]

The proposed image dependent brightness preserving histogram equalization (IDBPHE) [13] technique use the wrapping discrete curvelet transforms (WDCvT) and the histogram matching technique. A simple diagram of IDBPHE is shown in Figure 8(a) and the corresponding steps are given below.

- **Region Identification and Separation:** The curvelet transform is used to identify bright regions of an original image.
- **Histogram Computation and Matching**

- A histogram of the original image and the histogram of pixels which belong to the identified regions are computed.
- Modify a histogram of the original image with respect to a histogram of the identified regions

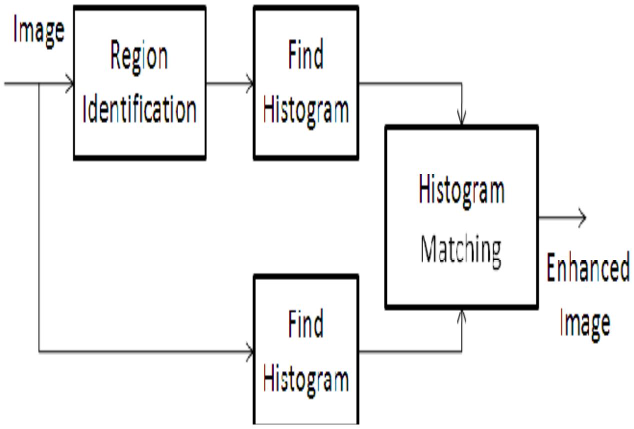


Figure 8(a): Flow Chart of IDBPHE

For region identification and matching the following flow chart will represent the procedure.

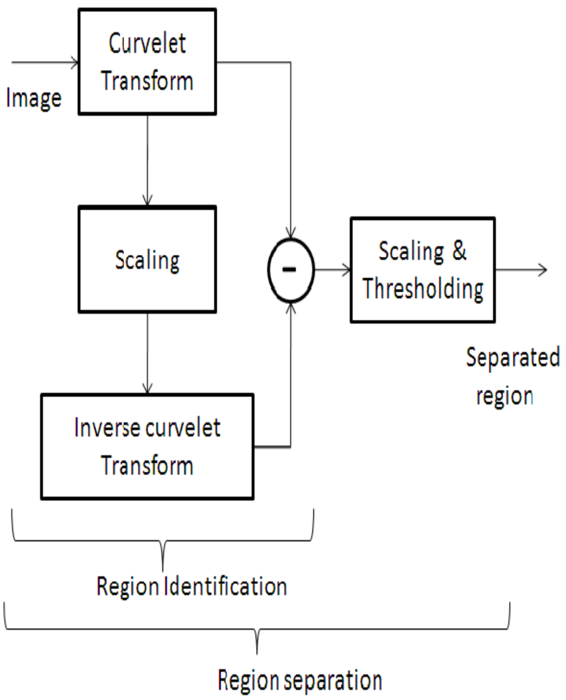


Figure 8(b): Flow Chart for Region Identification and Matching in IDBPHE

Peak Signal to Noise Ratio (PSNR) and Absolute Mean Brightness Error (AMBE) are used to evaluate the effectiveness of the proposed method in the objective sense.

AMBE (**X, Y**) = |**Mx – My**|

Where **Mx** and **My** represent mean values of the input image X and output image Y, respectively.

The PSNR is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAX_I is 2B−1.

It is most easily defined via the mean squared error (MSE) which for two m×n monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Global and Local transformation techniques produces the best image contrast enhancement as compare to other contrast enhancement techniques because these techniques produces images without undesirable artifacts and maintains input mean brightness.

CONCLUSIONS

Image contrast enhancement plays an important role to enhance the quality of an image. In this paper, the different image contrast enhancement techniques are compared and analyzed. The mixture of global and local contrast enhancement techniques improves an image quality better than the other image enhancement method. This technique improves the clarity or the visual impression of an image with preserving the brightness. This is proposed system, implementation work is going on. The major goal of image contrast enhancement is to produce images without the side effect of the technique which we are applying for image contrast enhancement. This technique improves the contrast of input image without disturbing the brightness.

III. RESULT AND DISCUSSIONS

In Histogram Equalization technique the brightness of the image is changed. Therefore this technique is not suitable for consumer electronics. The BBHE and DSIHE techniques separate the input histogram into two subsections based on mean value and median value respectively. The RMSHE, BPDHE and RSWHE techniques divides histogram into two or more subsections. In RMSHE techniques divides histogram into several subsections based on local mean values. In BPDHE technique divides the histogram into several subsections and equalizes them independently, division is based on local maximums of input histogram. In RSWHE technique divides input histogram into two or more subsections recursively, to modify sub histogram by means of weighting process based on normalized power law function.

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