A Survey on Image Contrast Enhancement

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Abstract: *Image Contrast enhancement without affecting other parameters of an image is one of the challenging tasks in image processing. The quality of poor images can be improved using various Image Contrast Enhancement techniques. Contrast is the visual difference that makes an object distinguishable from background. This paper presents the comparative study of some popular image contrast enhancement techniques such as histogram equalization, Brightness preserving bi-histogram equalization, Dualistic Sub image Histogram Equalization, Recursive Mean Separate Histogram Equalization and Minimum Mean Brightness Error Bi-histogram Equalization. Bi-histogram equalization preserves the original brightness to certain level. There are some cases that are not preserving well by Brightness Preserving Histogram Equalization as they require higher degree of preservation. Brightness Preserving Histogram Equalization referred to a Recursive Mean Separate Histogram Equalization to provide not only better but also scalable brightness preservation. Brightness preservation not handled well in Histogram Equalization, Brightness Preserving Histogram Equalization, and Dualistic Sub image Histogram Equalization but it is handled well in Recursive Mean Separate Histogram Equalization and Minimum Mean Bi-histogram Equalization*

Keywords: Bi-histogram Equalization, Dualistic Sub-image Histogram Equalization, Recursive Separate Histogram Equalization.

1. Introduction

The image contrast enhancement has been studied from the last past decade. Contrast enhancement produces an image that looks improve than the original image by converting the pixel intensities. Among various contrast enhancement approaches, histogram modification based methods have received the greatest attention because of its simplicity and effectiveness. In particular, since global histogram equalization (GHE) tends to over-enhance the image features, the approaches of dividing an image histogram into several sub-intervals and modifying each sub-interval separately have been considered as an alternative to GHE [6]. The effectiveness of these sub-histogram based methods is highly dependent on how the image histogram is divided. These image histograms are modeled using Gaussian mixture model (GMM) and divide the histogram using the intersection points of the Gaussian components. The divided sub-histograms are then separately stretched using the estimated Gaussian parameters.

HE performs its operation by reconstructing given pixels of the image based on the PDF of the input gray levels [9]. Generally, we can classify these methods in two important methods that is local and global histogram equalization. Global Histogram Equalization is the use of the transformation function of an entire input image using the histogram information [7]. Though this GHE approach is suitable for over-all enhancement, it failture with the actual brightness preservation of the input image. If there are some gray levels in the image normally dominate the higher frequency to the lower frequency. Local Histogram Equalization (LHE) tries to eliminate such problem.LHE use small window that slides through every pixel of the image sequencencilly.In local histogram equalization the block of small image pixel are fall in to the small window of local histogram equalization[10].

Histogram Specification (HS) is another method that takes a desired histogram by which the expected output image histogram can be controlled. However identifying the output Histogram is not an easy task as it changes from image to image. Another method called Dynamic Histogram Specification (DHS) is presented which generates the specified histogram dynamically from the input image. This method can preserve the original input image histogram distinctive. However, the degree of enhancement is not that much significant.

The different histogram equalization method has been studied such as Brightness Preserving Histogram Equalization, Dualistic Sub Image Histogram Equalization, Recursive Mean Separate Histogram Equalization and Dynamic Histogram Equalization. .

The above contrast enhancement techniques perform well on some images but they can produce problems when a sequence of images has to be enhanced, or when the histogram has points, or when a natural looking enhanced image in discipline manner required. In addition, computational complexity and controllability become an important issue when the goal is to design a contrast enhancement algorithm for consumer products. In short, our goal in this paper is to obtain a visually pleasing enhancement method that has low-computational complexity and works well with both video and still images [4].

To overcome the above mentioned problems using a new contrast enhancement algorithm that exploits the histograms of both color and depth images. In this technique the histograms of color and depth images are first divided into sub-intervals using the GMM. The intervals of the color image histogram are then adjusted such that the pixels with the same intensity and equal depth values can belong to the same interval. The proposed algorithm is thus implicitly depth adaptive. The rest of the paper is described as follows. Section II gives the Background of image enhancement. In

section III, describe the histogram method .In section IV Analysis and Application. In section V followed by the conclusion.

2. Image Enhancement

Image enhancement simplest and most important concept in digital image processing and it can be implemented by noise removal or contrast enhancement. The idea behind in image enhancement is to improve quality of given image or simply to highlight the certain feature of the image. A familiar example of image enhancement as shown in figure 1. In which when we increase the visual background of an image it looks better than original image improved image obtain by using various image contrast enhancement techniques .Contrast is a visual difference of image that make the object is distinguishable to the background. The contrast of the image is improved than the original image as shown the figure 1.

Image enhancement improved the contrast of the image in terms of brightness and the actual appearance of the processing image

Figure 1: Image Enhancement

3. Histogram

The histogram of digital images with the gray level in the range [0 to L-1] is a discrete function $p(rk) = rk/n$ where rk is kth gray level and nk is number of pixel in the image with gray level , n is total number of pixel in the given image and k = 0,1………L-1.

The histogram p (rk) of an image gives a global description of the image of the gray level rk. A plot of this function for all values of k provides a global description of an image. For example, fig. 2 shows the four basic types of Histograms of an image. The histogram shown in fig. 2 (a) shows that the gray levels are concentrated towards the dark end of the gray scale area. Thus this histogram is consistent to an image with overall dark characteristics. Just the converse is true in fig 2 (b). The histogram shown in the fig 2 (c) has a narrow shape, thus it corresponds to an image having small contrast. Finally, 2 (d) shows a histogram with significant spread, corresponding to an image with high contrast.

Histogram of giving image represents the global description of the given image or represent frequency occurrence. Histogram plot on x axis and y axis where the x axis represent the number of pixels in the image with gray level and y axis represent the total number of pixels in the given image. Four basic types of histogram these are

1. Dark histogram
2. Bright histogram
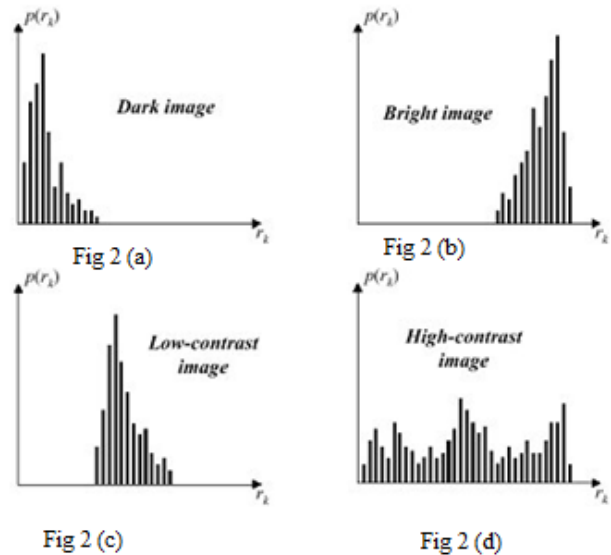3. Low contrast histogram
4. High contrast histogram

Figure 2: Four basic types of Histograms of an image

A. Histogram Equalization

This technique is widely used because it is simple and easy to invoke. This can be used for contrast enhancement of all types of images. It works by flattening the histogram and stretching the dynamic range of the gray levels by using the cumulative density function of the image. The most widely used application areas for histogram equalization is medical field image-processing, radar image processing, etc. The biggest disadvantage of this method is it does not pre-serve brightness of an image. The brightness get changed after histogram equalization. Hence preserving the initial brightness and enhancing contrast, are essential to avoid other side effect
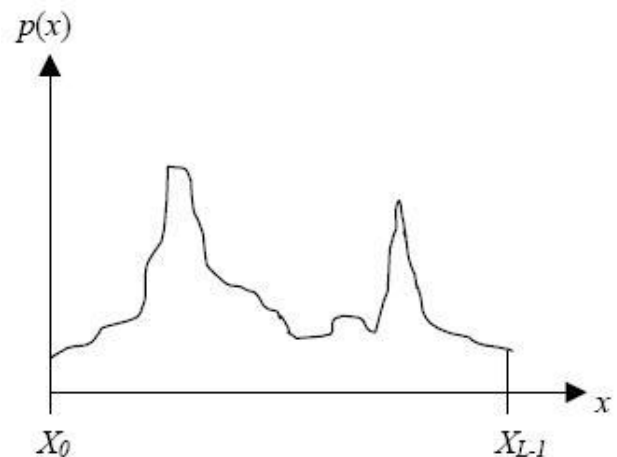

Figure 3: Simple histogram

Where xo to xL-1 represent 0 to 255 Gray-level and p(x) de-

notes number of pixels. In the above figure the input image is mapped into entire dynamic range using cumulative density function as a transform function. Histogram equalization has an effect of stretching the dynamic range of a given histogram since it flattens the density distribution of the image [5].

B. Brightness preserving bi-histogram equalization (BBHE)

In this technique, the input image is decomposed and two sub images. These two images are formed on the basis of gray level mean value. The drawback introduced by HE method is overcome by this method. Then HE method is applied on each of the sub-image
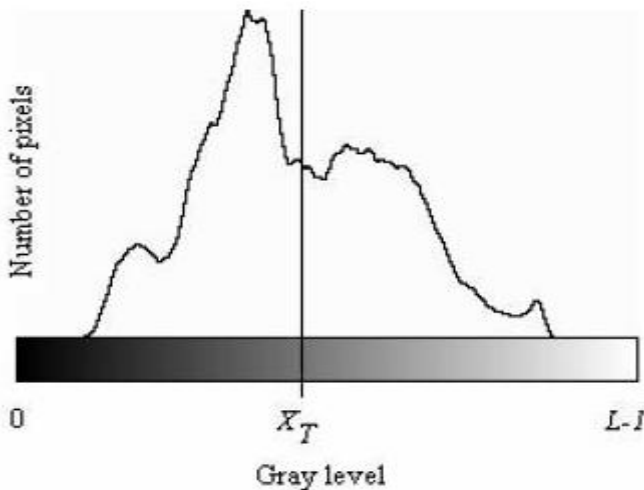

Figure 4: Bi- Histogram Equalization [2]

This method equalizes both the images independently. Their respective histograms with a constraint that samples in the first sub image are mapped into the range from minimum gray level to input mean and samples in the second sub-image are mapped into the range from mean to greatest gray level. The obtained equalized sub images are finite by each other around input mean. The output image produced by BBHE has the value of brightness (mean gray-level) located in the middle of the mean of the input image [5].

The Mean brightness of the image while enhancing the contrast is preserved using BBHE method. This is the main advantage of using this method.

C. Dualistic Sub image Histogram Equalization(DSIHE)

In this method the original image is divided into two equal area sub-images based on gray level probability density function of input image.The DSIHE technique for contrast enhancement decomposes an image into two equal area sub-images, and this two sub image handled alone. Obtained image of dualistic sub image histogram equalization (DSIHE) is obtained after the two equalized dark and bright will be composed into one image. This is similar to BBHE except difference is that in this method DSIHE chooses to separate the histogram based on gray level with cumulative probability density instead of the mean as in BBHE, i.e. alternative of break down the image based on its mean gray level pixel value, the DSIHE method break down the image aiming at the maximize of the brightness of the output image.

The particular of the original image's gray level probability distribution is decomposed [5].

D. Recursive Mean Separate Histogram Equalization (RMSHE)

In this method the image is separated on the basis of mean of input image. The term recursive used in RMSHE implies that in this technique instead of decomposing the input image only once, it breaks down recursively up to a recursion level r; therefore 2r sub images will be generated. Each sub image is then equalized along with the histogram equalization method. If recursion=0, that means no sub image break down is done, i.e. it is equivalent to HE method. If r=1 then it implies that it is equal to BBHE. The advantage of using this method is that the level of brightness preservation will increase with the increase of number of recursive mean separations. Though it is recursive in nature, Recursive mean separate HE also allows scalable brightness preservation, which is very useful in image processing.
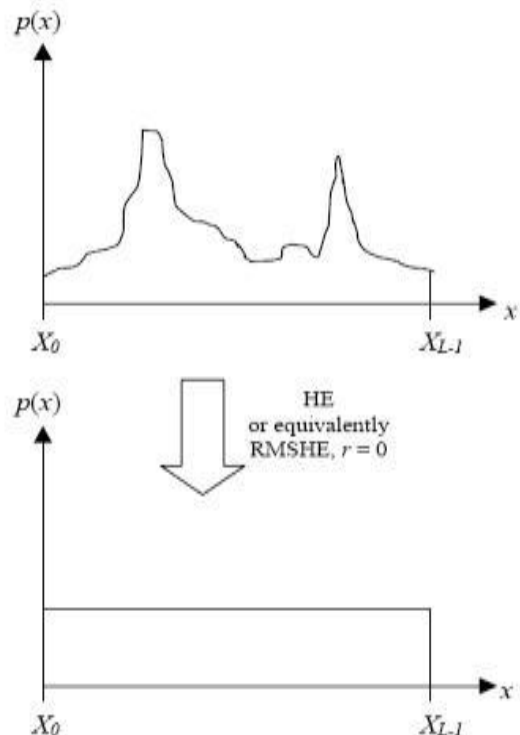

Figure 5: Histogram before and after HE or equivalently RMSHE value of r = 0 [3]

Figure 5 shows the. Histogram before and after HE or equivalently RMSHE value of r = 0 as we know in minimum mean brightness error Bi-histogram if the recursive value of decomposed image is zero then is equivalent to the histogram equalization otherwise the recursive value of decomposed image is one then it is similar to the Brightness preserving bi-histogram equalization as shown in the figure 6below. The main advantage of the recursive mean separate histogram equalization method is improving the brightness with the recursive level of giving break down an image.
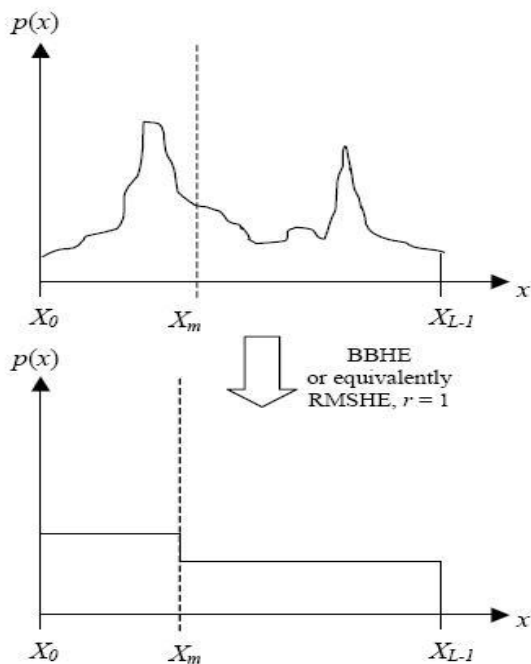
Figure 6: Histogram before and after HE or equivalently RMSHE value of r = 1 [3]

Based on threshold level found in Step 2 and equalizes both the histograms independently [2].

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

The basic principle behind this method is that decomposition of an image into two sub images and applying equalization process independently to the resulting sub images which is similar to BBHE and DSIHE except difference is that this technique searches for a threshold level lt, which decomposes input image into two sub images in such a way that the minimum brightness difference between the input and the output image is achieved. This is called absolute mean brightness error (AMBE). After this histogram equalization is applied to each sub image to produce output image. The steps taken in this process are as follows. 1. Absolute mean-brightness error is calculated for each possible threshold level. 2. Find a threshold level that yields low absolute mean brightness error. [3]

F. Dynamic Histogram Equalization (DHE)

The Dynamic Histogram Equalization (DHE) technique performs well than the traditional HE so that it can enhance an image without making any changing property for details in the given image. DHE divides the histogram of the input image into a number of sub-histograms until it ensures that no dominating portion is present in any of the newly created sub-histograms. After that, each sub histogram must go through HE and is allowed to occupy a specified gray level range in the enhanced obtained image. Therefore a better overall contrast enhancement is achieved by Dynamic Histogram Equalization with con-trolled dynamic range of gray levels and eliminating the possibility of the low histogram components being compressed that may cause part of the image to have washed out appearance [6].

4. Analysis and Application

The image contrast enhancement techniques are developed remarkably in the last decades. This Paper provides comprehensive discussion and table 1 show the advantage and disadvantage of different histogram equalization method.

Table 1: Comparison of Image Contrast Enhancement Techniques

Enhancement techniques	Advantage	Disadvantage
Histogram Equalization	Simple and effectiveness	The flattening property (unnecessary visual deterioration)
Brightness Preserving Histogram Equalization	Preserve the mean brightness of the given image	Higher degree of brightness preservation not possible
Dualistic Sub Image Histogram Equalization	Obtain image mean brightness is similar to input image	Cannot solve over equalization effect problem
Recursive mean Separate Histogram Equalization	Method has a good contrast enhancement effect	High time consumption because perform multi-equalization
Minimum Mean Brightness Error Bi-Histogram Equalization	More suitable for gray scale image	Not for image having heavy peak value

Most of the image contrast enhancement techniques preserve the brightness and the actual appearance of the image each techniques advantage and disadvantage discussed in this paper. Out of above discussed Techniques Recursive Mean Separate Histogram Techniques is useful for preserving brightness of the image. These Techniques are used in various sectors such as vision, remote sensing, dynamic scene analysis, autonomous navigation, and biomedical image analysis.

5. Conclusion

In this Paper, image enhancement based on prior knowledge on the Histogram Equalization has been presented. Many image enhancement schemes like Brightness preserving histogram equalization (BBHE) , dualistic sub Image histogram equalization (DSIHE),recursive mean separate histogram equalization (RMSHE), minimum mean brightness error bi-histogram Histogram equalization (MMBEBHE) has been studied. Different histogram equalization method concludes that brightness preservation is not handled well by Histogram equalization (HE),dualistic sub-image histogram equalization (DSIHE),brightness preserving histogram equalization (BBHE) but it is handled by properly by recursive mean separate histogram equalization (RMSHE),and minimum mean brightness bi-histogram equalization (MMBEBHE) .

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