Image Contrast Enhancement Techniques: A Report

Pankaj A. Mohrut[1], Dr. Deepti Shrimankar[2]

[1] *M.Tech scholar, Department of CSE, VNIT, Maharashtra, India*
[2] *Assistant Professor, Department of CSE, VNIT, Maharashtra, India*

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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 technique. Contrast is the visual difference that makes an object distinguishable from background. The basic aim of this topic is to provide an improved and good quality image by adjusting the amount of saturation and illumination to achieve more realistic and clear image. This paper presents the comparative study of some popular image contrast enhancement algorithms using histogram modification techniques such as histogram equalization, brightness preserving bi-histogram equalization, dualistic sub-image histogram equalization, recursive mean separate histogram equalization, dynamic histogram equalization and enhancement using color and depth image. However the conventional histogram equalizations methods have some of the drawbacks that are overcame by using joint segmentation method.*

Histogram based techniques are mainly based on equalizing the histogram of the image and increasing the dynamic range corresponding to the image [1]. As a result, such an image creates side-effects such as washed out appearance and false contouring due to the significant change in brightness. This drawback of histograms equalization method is overcame by image contrast enhancement algorithm using the histograms of color and depth images [9]. To overcome all the above stated weakness we proposed a new technique called as image contrast enhancement using joint segmentation method in which histograms of each intensity image is separately calculated and enhanced.

KeyWords: Contrast enhancement, Histogram equalization, Histogram modification, and Color and Depth image.

1. INTRODUCTION

Due to the advent of computer technology, image processing techniques have became increasingly important in a wide variety of applications. Contrast enhancement produces an image that subjectively looks better than the original image by changing 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 details, the approaches of dividing an image histogram into several sub-intervals and modifying each subinterval separately have been considered as an alternative to GHE. 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 remapping the gray levels of the image based on the probability distribution of the input gray levels [10]. Generally, we can classify these methods in two principle categories – global and local histogram equalization. Global histogram equalization (GHE) uses the histogram information of the entire input image for its transformation function [7]. Though this global approach is suitable for overall enhancement, it fails with the local brightness features of the input image. If there are some gray levels in the image with very high frequencies, they dominate the other gray levels having lower frequencies. Local histogram equalization (LHE) uses a small window that slides through every pixel of the image sequentially and only the block of pixels that fall in this window are taken into account for HE and then gray level mapping for enhancement is done only for the center pixel of that window[6][8]. Thus, it can make remarkable use of local information also. However, LHE has some disadvantage. It requires high computational cost and sometimes causes over enhancement in some portion of the image. Another problem of this method is that it also enhances the noises in the input image along with the image features. Most of the time, these methods produce an undesirable checkerboard effects on enhanced images.

Histogram specification (HS) is another method that takes a desired histogram by which the expected output image histogram can be controlled. However specifying the output histogram is not a 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 characteristics. However, the degree of enhancement is not that much significant [4].

Some researchers have also focused on improvement of histogram equalization based contrast enhancement such as Mean Preserving Bi-histogram equalization (BBHE), equal area dualistic sub-image histogram equalization (DSIHE) and minimum mean brightness error bi-histogram equalization (MMBEBHE). This method tries to overcome the brightness preservation. DSIHE method uses entropy value for histogram separation. MMBEBHE is the extension of BBHE method that provides perform good contrast enhancement, they also cause more annoying side effects depending on the variation of gray level distribution in the histogram [5]. Recursive mean separate histogram equalization (RMSHE) is another improvement of BBHE. However, it is also not free from side effects. Image contrast enhancement using histogram of color and depth image is more effective than other techniques available. 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 rest of the paper is organized as follows. Section 2 gives the literature survey. In section 3, results and discussion are explained followed by problem formulation in section 4. Finally Section 5 gives conclusion.

2. LITERATURE SURVEY

2.1 Histograms Equalization

This technique is widely used because it is simple and easy to implement. 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 preserve brightness of an image. The brightness get changed after histogram equalization. Hence preserving the original brightness and enhancing contrast are essential to avoid other side effects.

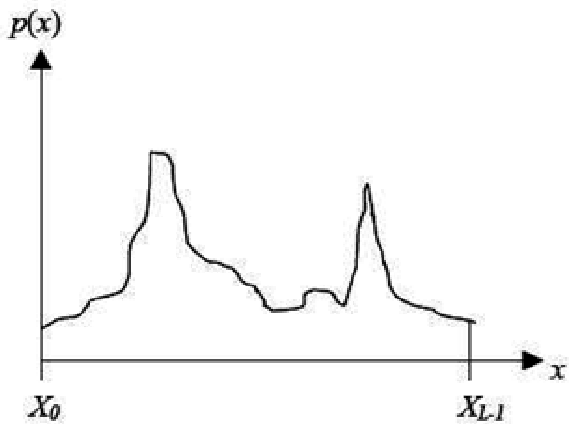

Figure 1: Simple Histogram

Where x_0 to x_{L-1} represent 0 to 255 Gray-level and p(x) denotes number of pixels. In 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 [6].

2.2 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-images. This method equalizes both the images independently. Their respective histograms with a constraint that samples in the first sub-image are mapped in the range from minimum gray level to input mean and samples in second sub-image are mapped in the range from mean to maximum gray level.

The resultant equalized sub-images are bounded 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 [6].

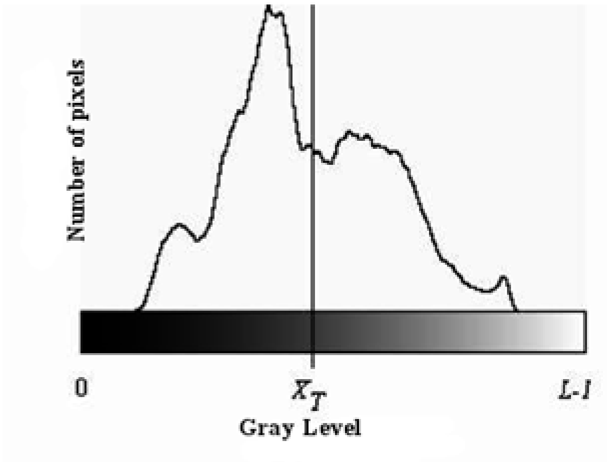

Figure 2: Bi-histogram equalization

2.3 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, one dark and one bright, following the equal area property. Resulting image of dualistic sub-image histogram equalization (DSIHE) is obtained after the two equalized sub-images 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 equal to 0.5 instead of the mean as in BBHE, i.e. instead of decomposing the image based on its mean gray level, the DSIHE method decomposes the image aiming at the maximization of the Shannon's entropy of the output image. The aggregation of the original image's gray level probability distribution is decomposed [6].

2.4 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 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 as shown in fig 3. If r=1 then it implies that it is equivalent to BBHE as shown in fig 4. 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, RMSHE also allows scalable brightness preservation, which is very useful in consumer electronics [3].

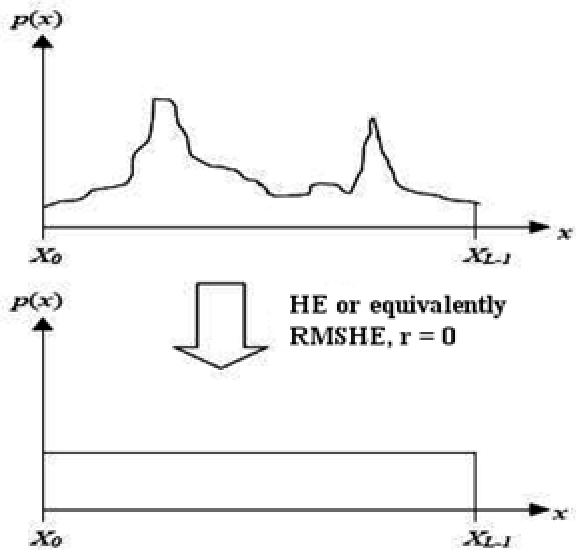

Figure 3: Histogram before and after HE or equivalently RMSHE value of r=0

2.5 Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE)

The basic principle behind this method is that decomposition of 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 It, 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 on 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 yield minimum absolute mean brightness error.

3. Separate the input histogram into two histograms based on threshold level found in Step 2 and equalizes both the histograms independently [2].

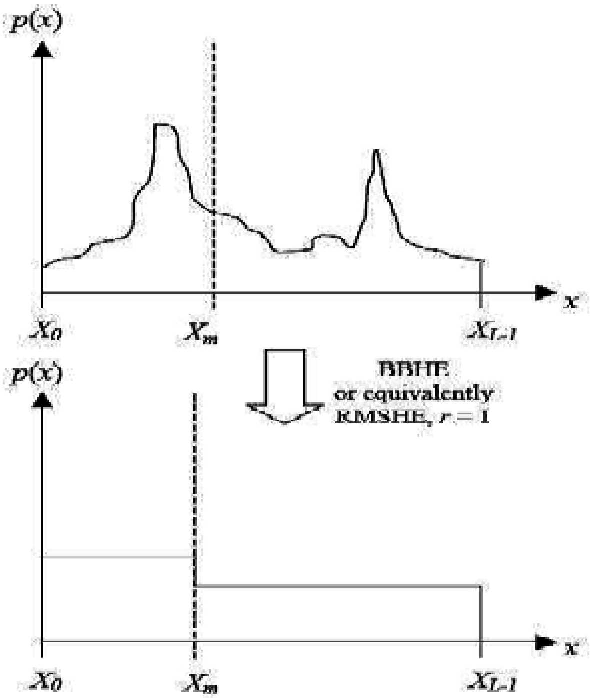

Figure 4: Histogram before and after HE or equivalently RMSHE value of r=1

2.6 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 loss of details in the image. DHE divides the histogram of 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 output image. Therefore a better overall contrast enhancement is achieved 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 part of the image to have washed out appearance[7].

2.7 Contrast enhancement using color and Depth Histograms

In this method, the histograms of color and depth images are used for enhancement. On the basis of the histogram modification framework, the color and depth image histograms are first partitioned into subintervals using the Gaussian mixture model. The positions partitioning the color histogram are then adjusted such that spatially neighboring pixels with the similar intensity and depth values can be grouped into the same sub-interval. By estimating the mapping curve of the contrast enhancement for each subinterval, the global image contrast can be improved without over-enhancing the local image contrast. This method modifies the histogram of the color image using the histogram of the as side information [9].

3. RESULTS 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, MMBEBHE and DHE techniques divides histogram into two or more subsections. In RMSHE techniques divides histogram into several subsections based on local mean values. In these techniques instead of decomposing the input image only once, it is decomposed recursively until certain level of a recursion. DHE with controlled 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. So the best results are generated by Image contrast enhancement of color and depth image. But one of the disadvantages of this method is the time required for enhancement is more than one minute [9]. Whereas in joint segmentation method it is expected that this time required will be less. In this depth map information is used for enhancing the original low contrast image. We plan to use binary segmented image in our approach. The saliency map is also required for generating depth map from the original low contrast color image. Finally we expect higher peak signal to noise ratio and minimum mean squared error value in reconstructed image so that we get high quality output image in less time

4. PROBLEM FORMULATION

Generally in enhancement of image contrast there are chances of affecting other factors such as brightness, quality of image and pixels intensity. In addition to preserve these factors we also have to focus on the time required for enhancement along with computational complexity and controllability. It is expected that this joint segmentation method will removes all these drawbacks. So we will try to implement segment based approach using depth map and saliency map so that the time required for enhancement will be less as compared to existing techniques.

5. CONCLUSIONS

In this paper we discussed several image contrast enhancement techniques along with their advantages and disadvantages and the improved versions of histogram modification technique to enhance histogram based image contrast using color and depth image. The Gaussian Mixture Model (GMM) is used for partitioning the image into subintervals to obtain layer labeling results of color and depth images. The pixels of equal intensity and same depth value are grouped together such that they are in same layer which will help to improve image contrast without over enhancement. We plan to extend layer based algorithm to a segment-based algorithm by using a joint color-depth segmentation method. It is expected that the enhancement using joint segmentation method improves the computational speed, complexity and drawbacks of other enhancement techniques.

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BIOGRAPHIES

Pankaj A. Mohrut has received bachelor of engineering degree in Information Technology from SGBAU University and currently pursuing M.Tech in Computer Science And Engineering from Visvesvaraya National Institute of Technology. The area of interest is image processing.

Dr. Deepti Shrimankar is currently working as assistant professor in Visvesvaraya National Institute of Technology. She has done her M.tech in computer science and engineering. Her area of interest is Parallel and Distributed Systems, Embedded Systems, Computer Networks. She has received Ph.D in parallel and distributed system.

