A Project Report on

Image Contrast Enhancement using Recursive Division Based Histogram Equalization

Submitted in partial Fulfilment of the requirement for the Degree

Of

MASTER OF TECHNOLOGY

In

COMPUTER SCIENCE AND ENGINEERING

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JUNE, 201

DECLARATION

I hereby declare that the Major Project-II **"Image Contrast Enhancement using Recursive Division Based Histogram Equalization"** which is being submitted to Delhi Technological University, in partial fulfilment of awarding the Master in Technology (Computer Science and Engineering) is a bonafide report carried by me. The material in this Report has not been submitted to any university or institution for the award of any degree.

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CERTIFICATE

This is to certify that Major Project-II Report entitled **"Image Contrast Enhancement using Recursive Division Based Histogram Equalization"** submitted by**,** Sanjay Kumar Roll No. 2K14/CSE/25 as a partial requirement for the award of Master of Technology degree in Information Systems by Delhi Technological University.

The major project is a bonafide piece of work carried out and completed under my supervision and guidance during the academic session 2013-2015. The matter contained in this report has not been submitted elsewhere for the award of any other degree.

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ACKNOWLEDGEMENT

First of all, I would like to express my deep sense of respect and gratitude to my project supervisor Mr. Anil Parihar for providing the opportunity of carrying out this project and being the guiding force behind this work. I am deeply indebted to him for the support, advice and encouragement he provided without which the project could not have been a success. Secondly, I am grateful to Dr. O.P.Verma, HOD, Computer Science & Engineering Department, DTU for his immense support.

I would also like to acknowledge Delhi Technological University library and staff for providing the right academic resources and environment for this work to be carried out. Last but not the least I would like to express sincere gratitude to my parents and friends for constantly encouraging me during the completion of work.

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ABSTRACT

Today, Images are most elaborative form of information. Images used in every field of engineering and science. Ex. NASA images, Satellite Images, Medical Science, Manufacturing industry quality control images.

Whenever image is taken by Satellite or By the medical photography for medical purpose, it has noise and poor quality in form of brightness, contrasts, blurred, etc. because of poor quality of light and noise between the camera lens and object. Hence before analysing the image, it needs to be enhanced. Enhancement depend on the type of artifact in image and the purpose for which image will be used or type of information we want from image.

Images taken by satellite or by camera in poor light has poor contrasts quality. Hence objects in image have not visible properly. To increase the contrasts of the image we use Histogram Equalization technique. In the proposed algorithm image is divided into sub-images using histogram and histogram equalization take place on each sub-segment independently. Then join the segment to produce final image. Sometime our method loss natural appearance, to gain the natural appearance Image Normalization concept is used. And to segment the image into sub-segment used a threshold intensity value is used. This value has many selection criteria like median mean, otsu ant many other strategy too.

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CHAPTER 1

INTRODUCTION

1.1 IMAGE

Image is a representation of externals of person or object or anything. Images are of two type, Analog image and Digital Image. Image is a two dimensional function f(x, y) where x and y are co-ordinate in spatial and f is the amplitude value (intensity or gray level). In case of digital image value of f is finite where in case of analog image these are infinite value. Our interest is Digital image because they can be processed by computer. And these point f(x, y) called pixel or image element [1]. Each the pixel have values based on type of image. If it is a gray image have range 0-255 and if it is a colored image have set of three values (R G B). First question is whatever we see is an image. How it is formed? And what the actual, meaning of image.

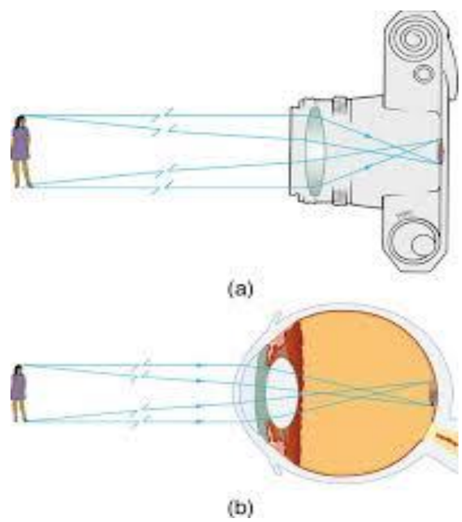


Fig. 1 Image view [30]

As shown in Fig-1 basic principle of image formation. Hence we can say image is nothing but collection of different intensity of visible light (300nm-700nm). Digital image consist of discrete intensity value. These intensity have their own range (gray image 0 to 255) and responsible for how an image look. These discrete pixel value are stored by camera on storage device that can be processed latter.

1.2 TYPES OF IMAGES AND THEIR QUALITY ISSUE

Images have different format of representation for different purpose. JPG, PNG, BMP, TIFF, PGM etc. But computer understand them only as a 2-d matrix (gray image) consist of pixel value of all image element [1]. But these format are only used for storage of image for saving memory while sacrificing other quality issues of image. Depending on the size of image and purpose of image we decide which format should be used for storage of image. For General image like human image we can allow loss of some pixel because losing these pixel does not affect too much quality of image and content of image. But in case of astronomical images taken by satellite have information in each pixel, we can't tolerate loss of any information in this case because a lot of already lost because of distant image and noise in environment. Hence we use different method for enhancement of image depending on type of image. We know that during image enhancement some unnatural artifact always introduced like loss of natural appearance in case of gamma-images we can tolerate this artifact while increasing contrast of image hence more visibility of bone in medical gamma-images.

1.3 IMAGE SENSING AND ACQUISITION

As we know all images are produced by the combination of illumination of source and the reflection or absorption of energy from the source by the element of object. As light reflected from the plane surface of an object or x-ray passes through a body for the purpose of generating a diagnose of internal structure of object, how much light is absorbed and reflected by body parts, we got a view of structure [1]. It is used for human body X-ray, to check the breakage of bone.

Image acquisition let's say f(x, y) is an image intensity, we know range of f(x, y) from 0 to ∞. But we can't store the ∞ value on computer or anywhere else. And we need to specify a range $0 <= f(x, y) <= L - 1$. Where L is the highest level. For gray image its value L=256.

$$f(x, y) = I(x, y)\, r(x, y) \qquad (1)$$

r (x, y): reflection component.

I (x, y): illumination intensity.

1.4 HISTOGRAM EQUALIZATION

It is a fast and good contrast enhancement technique [2]. It used on all type of images and improve the contrast on image by expanding the range of intensity from 0 to MAX (intensity). It is widely used because of its simplicity and applied on all type image medical, satellite, and darker image. By experiment we found that it work fine on a lot of images but fail on most of images. And it change the brightness of image after HE, because of flattering property of HE. Because of this it never used in electronics products ex. TV or where original image brightness preserving matter for us. What we do in HE. HE redistribute all intensity based on their probability in image.

Let say f (i, j) denote the image that have intensity levels as$\{I_0, I_1, I_2 \ldots I_{L-1}\}$;Where X(i, j) represent the intensity of image element at location (i,j). For such image probability density $pdf(X_k)$ [1,2] defined as:-

$$pdf(X_i) = \frac{N_i}{n} \quad (2)$$

N_i = total Number of pixel having intensity I_i in the image. Where i= 0, 1, 2…………L-1;
n=total number of pixel in image.

Now based on $pdf(X_k)$, $cdf(X_k)$ is manipulated as:-

$$cdf(X_K) = \sum_{i=0}^{k} pdf(X_K) \quad (3)$$

Transformation function f(x) that is used to transform the input intensity to output intensity is defined as:-

$$f(x) = X_0 + (X_{L-1} - X_0) * cdf(X_i) \quad (4)$$

Hence output image:-

$$Y = f(X)$$
$$= \{f(X(i, j)) \mid \text{for all } X(i, j) \in X\} \quad (5)$$

We can easily understand the HE by comparing the histogram (Fig 3) of original image and respective histogram (Fig 5) shown below. This is original image having very low contrast such that nothing is visible. This image probably taken early morning or late night.

Figure-2 Image Histogram, as we can see this image is not fully utilizing full gray level. That's why contrast is low.

Fig. 2 Earlier Morning Low Contrast Image

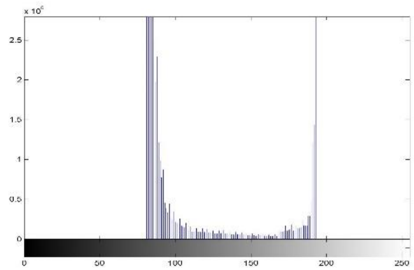


Fig. 3 Histogram of Fig(2)

Modified image in Fig (4) using HE. Having better contrast comparing to original image in Fig(2).

Fig. 4 HE image of Fig(2)

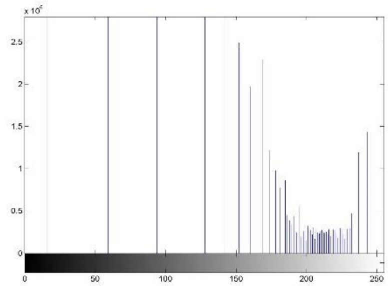


Fig. 5 Histogram of Enhanced Image

As we can see resultant image consist of all gray level 256. And also notice that image obtained after HE brighter than the original image. Contrast of a image also reduced because of excessive change in brightness, same thing happen with the HE where contrast improved well but because of other factor like change in natural appearance and over enhancement of white portion of image overall lead to decrease in contrast[1, 2], Because image have high density of lower gray level pixel. We does not use HE for contrast Enhancement because during enhancement of image it does not count the mean brightness of the image. To remove over-brightness many method have been proposed explained later in this literature. Each one introduce some artifact and we remove them using other technique.

1.5 BI- HISTOGRAM TECHNIQUE

We divide the pixel in two category based on mean or median of image intensity. Now we have two Histogram one containing pixel of intensity lower than mean and other contain intensity pixel greater than mean [1, 3]. Both of them are equalized separately and joined to get final image. We found that contrast enhancement is good compare to simple HE. Reason behind using the Bi-HE is because it consider the mean brightness of the image. In Bi-HE because we divide the image in two segment based on mean lead to preserve the brightness based on mean value. It is used in electronics devices because of its less computational complexity and mean brightness preserving.

This diagram showing the use of Bi-HE into electronic having same complexity as HE, because of parallel processing. A Better approach than HE to preserve the mean Brightness.

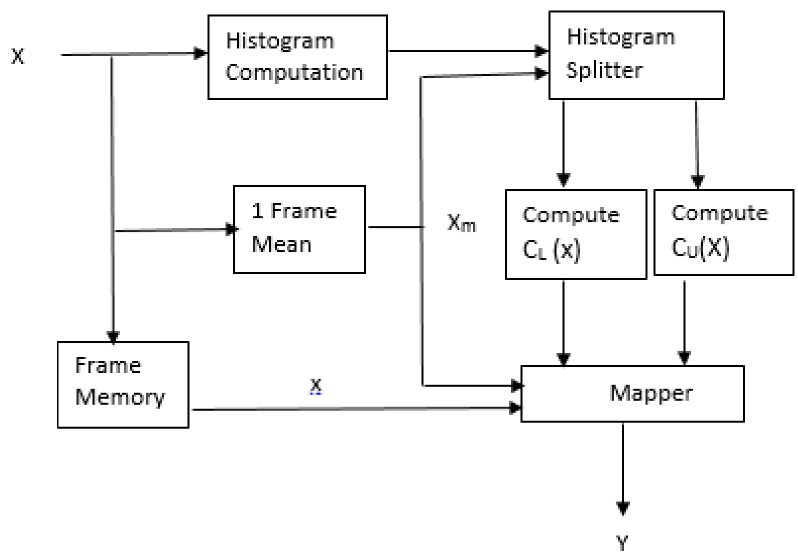


Fig. 6 Bi-HE used in electronic devices

Till now we discuss about Histogram Equalization and see what its artifact is and try to remove by using Bi-HE. But He also have many problem like loss of natural appearance, over enhancement, intensity saturation, Hence we got an idea of image segmentation based on some factor like median , mean, same number of pixel in each segment, Otsu, local minima and maximum minima and many more . Then each segment is equalized separately and whole image is combined into one. Some more concept like clipping the histogram and normalization of final image also used. Based on all these concept different Histogram Equalization Technique has been researched. We will give a brief introduction about all these technique.

1.6 IMAGE SEGMENTATION METHOD

1.6.1 MEAN

Mean intensity if find out based on input image. Now image id divided in to part. Subimage1 having all pixel with the intensity less than or equal to mean intensity, and second subimage2 having all pixel with intensity greater than mean intensity [7]. This concept is mainly used for preserving the mean brightness of the image. We can also further divide both sub images into more sub images recursively based on mean intensity of each sub image [1, 3]. This is recursive approach and extend based on our requirement of up to what level we want to preserve the mean intensity of image. But as number of segment increase complexity of processing that image also increases, multiprocessing help in reducing the time but it not always present in every electronic device [1]. Hence need to restrict the number of segment used for image processing.

1.6.2 MEDIAN

Here in place of mean, median is calculated to segment the image [1, 7]. Like previous method recursively increase the number of segment. It is helpful when image have one sided histogram bin of large height compare to other sided histogram bin height. Have same issue like loss of natural appearance etc.

1.6.3 OTSU

It is a nonparametric method for automatic threshold value (intensity) selection for any type of image. It uses the concept of separate-ability between different classes in gray level. This procedure use the first and second order cumulative distribution in gray level histogram. We can also expand the Otsu for multi-threshold value. otsu can be easily expand to gt more than one threshold value at once. But as the number of segment increases effectiveness of otsu also decreases [15]. Hence when we need more than two segment, a recursive approach can be used which give very precise result for segmentation. To extract the object from their background need a very precise threshold value that can draw a line between intensity values of background and object intensities. For this need to analyze the histogram. A histogram having deep and sharp valley between peek representation of object and background. However it's not always easy to have a sharp valley to get the threshold value. In most of the histogram there is no sharp distinction between background and object pixel. Valley sharping technique can be used to get threshold value or information concerning of neighboring pixel that can help in detection edges hence help in deciding threshold value. In case of simple textual document and simple industrial manufactured component's images have a sharp distinction between foreground and background object. Because their natural way taking the image. Implementation can be checked from code submitted.

1.7 NARROW RANGE SEGMENT

When Histogram is divided into segments and each segment equalized separately and independently lead to loss of natural appearance. This occur because of dominating factor height of bins in histogram. To remove this drawback Multi-HE proposed [10]. In this approach image is segmented into more than two segment using mean or median. Because here are multiple segment it may lead to narrow segment; narrow segment are those segment that have high number of pixel over a very small range of intensity, and these pixel are most dominating in image view. If we expand those pixel only in that small range it does not show any enhancement. Hence we identify these narrow segment and expand those over a full range of intensity level. Because in narrow segment most of pixel lies in very narrow range that why they need to expand over full range. After HE normalization is applied to avoid the saturation of intensities. Why we need to identify the narrow range segment? Segmentation based equalization says that each segment should be expand within their range. It is ok if histogram of image is smooth in that case each segment contain near about same width of intensities. But when histogram of image is not smooth, like cos sine wave. In this case when we segment the histogram in sub-segment, some segment are very narrow. They have range of their intensity very small such that when histogram equalization is applied on those segment, have no improvement in contrast, because they have nothing to expand, so give them a large range for histogram expansion so that such large number of pixel can be expanded easily.

As shown on Fig. 7(a) Histogram of a image divided on 4- segment based on some threshold values t1, t2, t3.

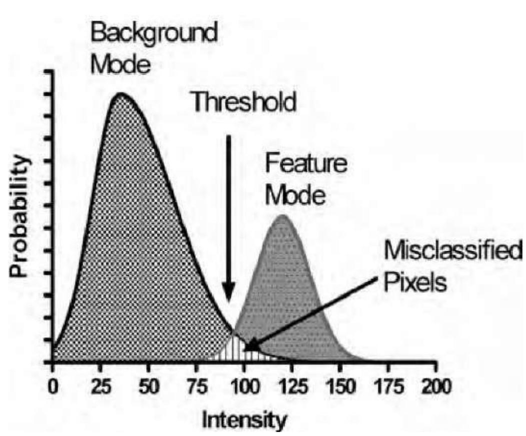
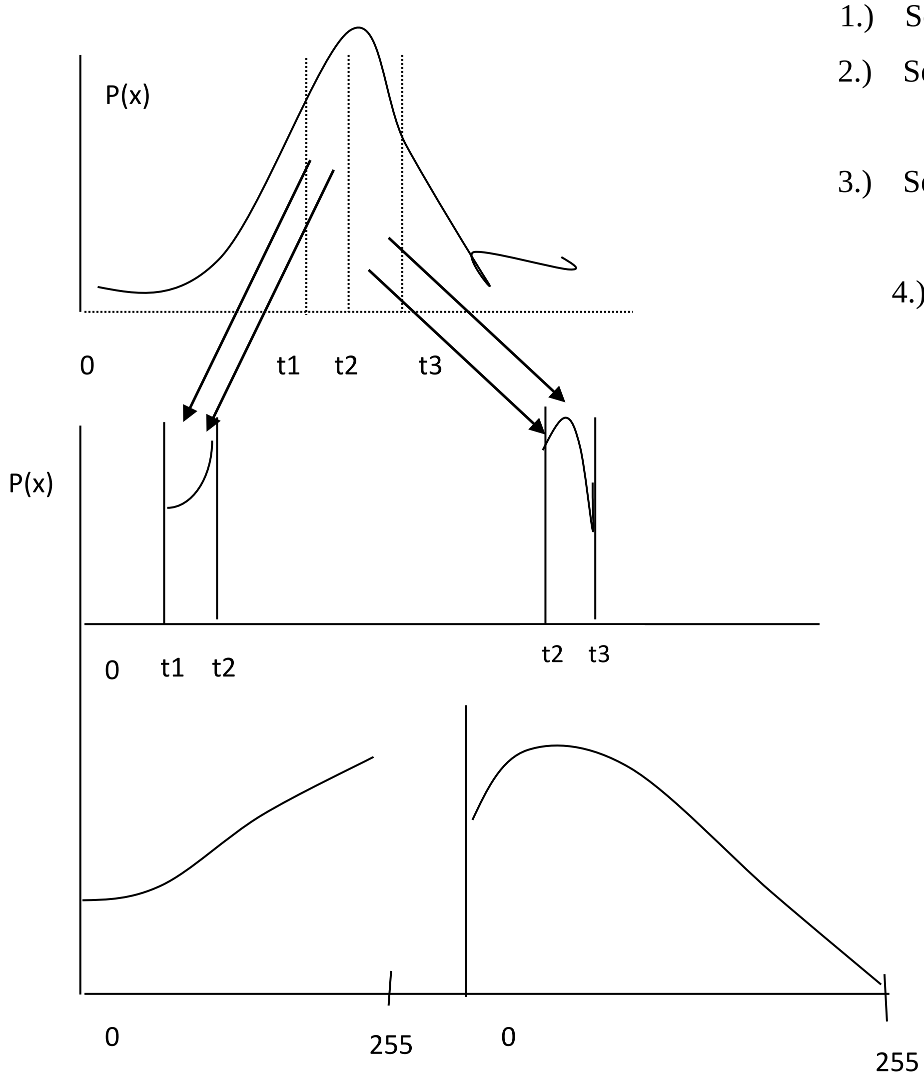


Fig.(7) Source of image[31]

This the simplest way to finding the Threshold value for background and Foreground separation. Although have some misclassified pixel. That can be resolved using neighborhood property.



1.) Segment-1 from intensity 0 to t1.
2.) Segment-2 from intensity t1+1 to t2.
3.) Segment-3 from intensity t2+1 to t3.
4.) Segment-4 from t3+1 to 255.

Fig. 8 Narrow range expansion of Histogram

As shown in fig. histogram is Divided into 4- segment using each having same number of pixel. Here as seen segment-2 and segment-3 come under the category of narrow segment. As shown in fig (b). Both are expanded for output gray range over full range 0 to L-1.

Exiting HE method equalize the sub-histogram only within their range because they have sufficient expansion for those pixel as seen in previous section. But narrow segment have closing point near to each other. If we expand them only within their range lead to intensity saturation. Because of this image loss its natural appearance. Hence before Equalization it try to expand the range to full range. Pointing out narrow segment need some type comparison with other sub=-

segment. We check that how much range to this sub-histogram hot allocated compared to other histogram range, if they are near about equal then its ok, otherwise this histogram declared as narrow segment using the below formula f(s). If f(r) < 1 for any sub-segment, it is declared as narrow segment. Narrow segment identification Algorithm as explained [10].

$$f(r) = (n/L-1)*(K_u^{r,n} - K_l^{r,n}); \quad (6)$$

where r=1, 2…….n; n is the total number of segment.

$K_l^{r,n} = 0$ and $K_u^{r,n} = L-1$ for first segment.

Algorithm:-

```
For: 1 to n
        Range(r) = (K_u^{r,n} - K_l^{r,n});
        f(r) = (n/L-1)*range(r);
        if f(r) <1
                new range(r) = L-1;
        else
                new range(r) = range(r);
        end
  end
```

1.8 CLIPPING THE HISTOGRAM

Another type of histogram Equalization Technique that is still being under study called clipped histogram equalization. By clipping the histogram before histogram equalization take place can restrict the enhancement factor. It helpful in avoiding the over amplification of noise. Clipping process can be applied with other method without any problem to check its effectiveness [12]. It is required to set the clipping parameter manually, hence not too much effective. We want a method that set the clipping parameter automatically based on image property or distribution of intensity over pixel. So that automatic image enhancement can take place in electronic device without the intervention human. SAPHE select the clipping parameter automatically using mean value of the non-empty bins of histogram and by analyzing the local peak of the image histogram. If SAPHE fail to detect any local peak then it fail to set the parameter locally.

MSAPHE introduced to remove this limitation, it set the plateau limit for finding the mean value of the non-empty bins of histogram and this mean is used as the clipping threshold for that histogram. Need to talk about Histogram to understand the concept of clipping process. What histogram does it expand the intensity of high region pixel and suppress the intensity expansion of the low region pixel. Hence when an object of interest inside an image lies in a small portion of image or have very small range of pixel in that case our interested object does not enhanced as needed. Because remaining portion of the image enhanced too much which suppress our interest of object. Histogram Equalization shift the intensity from left side of histogram to the right side of histogram it cause the level saturation. By clipping the histogram we try to avoid discussed problem that is shift of mean brightness and level saturation. Then we know enhancement rate directly depend on the cumulative density function cdf(x). So if we want to control the enhancing of image we can do this by controlling the values of cdf(X) and pdf(x).Clipped histogram equalization change the histogram by increasing or reducing the bins value based on threshold value selected by median process. This is known as clipped histogram or plateau limit level of histogram. The clipped portion of histogram then redistributed to all bins of histogram. The histogram Equalization process applied on the new Histogram obtained after clipping process. We are facing the two main problem first one to set the threshold value manually hence not able to implement this method for automation of HE on tv and other electronic devices. SAPHE choose clipping threshold automatically, but procedure is very complex and fail for most of the images. Some method put the clipped weight on histogram that's also depend on the user.

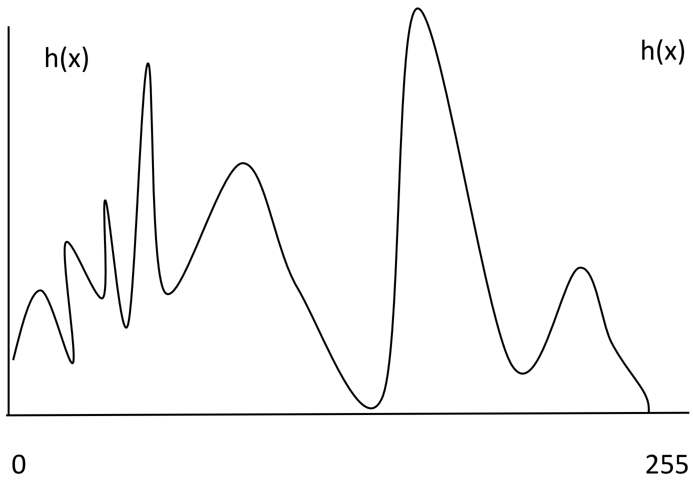


Fig. 9 Histogram of an Image

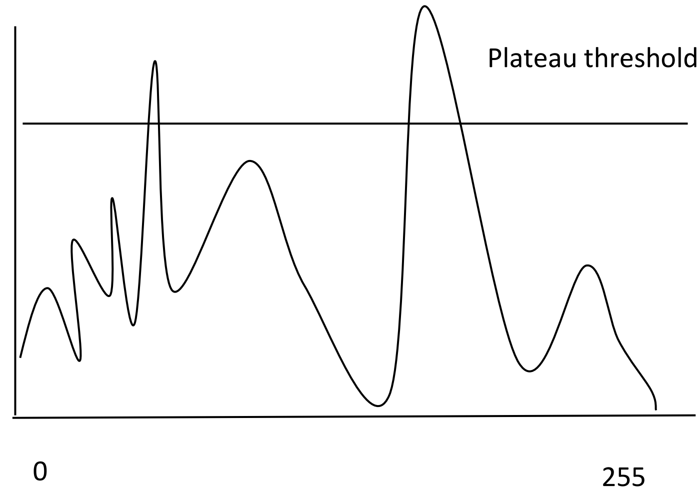


Fig. 10 Histogram showing plateau threshold

This is a random histogram of any given image. We see some peak point of bins, here we set Plateau limit manually as shown using median of non-empty bins.

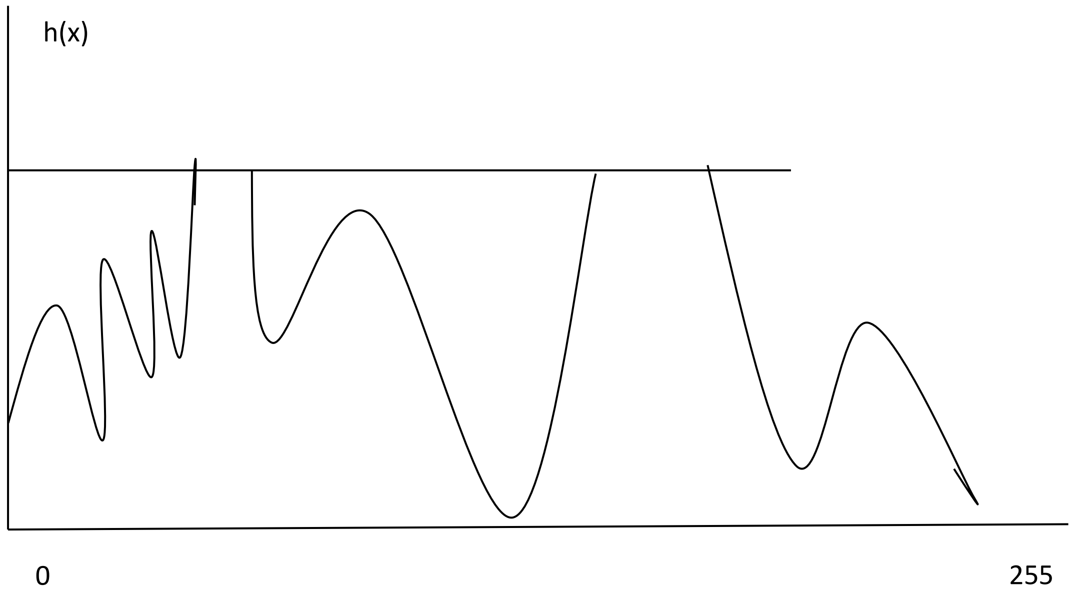


Fig. 11 Clipped Histogram

HE take place on the clipped Histogram. As we previously read about clipping concept and how it is helpful in image processing to enhance the small dominating portion of image. Clipping also used with the segmentation in which each segment clipped off separately to get better result. When we use segmentation each segment set their plateau limit according to their sub-histogram bins, based on median or mean of non-empty bins.

1.9 IMAGE QUALITY INDEX

We need to find a quality index for image that can be used for all type of images.it is effective and easy to calculate. Uses of traditional error-summation method are out dated and not too much effective. An index is designed by analyzing the factor of image: loss of correlation, luminance distortion, and contrast distortion. No human is involved for these manipulation everything have a mathematical proof and test done by us on various images shows that it perform better than distortion metric mean squared error that's why we advise to use the Quality index of image to measure its distortion take place after enhancement. [16]. Measurement of Image Quality help us to take the best one out of two or more image enhancement application. We can divide the quality assessment or image distortion in two classes, the first one mathematically defined formulas which are widely used by image enhancement application to measure the effectiveness of image enhancement application. It is PSNR (peak signal to noise ratio), MSE(mean squared error), SNR(signal-to-noise ratio), RMSE(root mean squared error), MAE(mean absolute error) [1]. Second class of measure is the human visual system that try to measure the quality difference in both images by observing the image view. However sometime it is the best factor to measure the enhancement done, but it can be observed the only special technical person, not by every common man. But no one ever show the clear advantage over Mathematical measurement term ex. PSNR and MSE using quality testing condition and different form of image distortion technique are consider for testing purpose. Mathematically formula for quality of image are more general in use because of these formula easy to calculate and have very low time complexity of manipulation. And all these free from viewing and observing capability of individuals. But we know viewing class of quality measurement play important role because of human view about image quality an image quality is good only if it is liked by human being and totally understandable by human whatever be the quality of that image if it make clearer perception of human about that image view then it is good. As we know there is no fixed and specific data for image analysis. In different viewing environment, viewing class of quality assessment produce different result in different environment and sometime inconvenient to be analyzed. So it's the observer responsibility to measure the human perception of viewing condition and calculate the condition input parameter. And the viewing perception of human in condition independent environment give only a general idea about the goodness of image. Here we are defining a mathematical model for image quality called universal image quality index. The word "universal", used because quality measurement of an image in this approach does not depend on the images that is going to be tested, and also the individual observers or viewing conditions does not matter. Most important it could be applied in different image enhancement tools for quality measure using different kind of image distortion known to the application. Although the MSE and PSNR have questionable performance but still called as "universal".

Let $x=\{x_i \mid 1,2,\ldots\ldots N\}$ and $y=\{y_i \mid i= 1,2\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots,N\}$. X represent the original image and y is the image for test. Quality index of test image defied as.

$$Q = \frac{4\,\sigma_{xy}\,\overline{x\,y}}{(\sigma_x{}^2 + \sigma_y{}^2)\ [(\bar{x}^2) + (\bar{y}^2)]} \tag{7}$$

Where,

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

$$\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$$

$$\sigma_x^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2 \tag{8}$$

$$\sigma_y^2 = \frac{1}{N-1}\sum_{i=1}^{N}(y_i - \bar{y})^2 \tag{9}$$

$$\sigma_{xy} = \frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})\,(y_i - \bar{y}) \tag{10}$$

Where dynamic range of Q is -1 to 1. When $Y_i = X_i$ give the best value 1, for all i=1,2,3,4,…..N. and when $Y_i = 2\bar{x} - x_i$ it lead to lowest values -1, for all i=1,2,3,4,5…..N. The Quality index model discussed have three factor luminance distortion, loss of correlation and contrast distortion hence quality index take care of all these factor and give value accordingly between -1 to1. Hence to see all these three factor present in our model we rewrite the model equation as shown below.

$$Q = \frac{2\bar{x}\bar{y}}{(\bar{x})^2+(\bar{y})^2} * \frac{\sigma_{xy}}{\sigma_x\sigma_y} * \frac{2\sigma_x\sigma_y}{\sigma_x^2+\sigma_y^2} \qquad (11)$$

Three equation in multiplication represent the three factor discussed. The first component is the correlation coefficient between input image (X) and output image or tested image (Y), who give the degree of correlation between input and tested image whose dynamic range lies within [-1, 1]. When $Y_i = a X_i + b$, it give the best value for i=1,2,3,4……………..,N. a and b be the constant where a>0. As we know input and tested image are linearly related but still they may have relative distortion. Between input image and test image. And this relative distortion is evaluated in 2_{nd} and 3_{rd} component of model. Second component measures the mean luminance between input and tested image its value lies within range [0, 1]. If $\bar{x} = \bar{y}$ Maximum value goes to 1. We can say third component is the measure of similarity of contrast of input image and test image. And estimated contrast of the input image represent by σ_x . and for tested image estimated contrast represent by σ_y . and range value of third component also lies in [0 1]. And it is achieved by only if $\sigma_x = \sigma_y$. Because it is desired to evaluate the complete image quality at once. And we know image signal are nonstationary, and quality of image effected by space variant. By considering all these fact apply the quality measurement locally by using a matrix A*A. now moving this matrix pixel by pixel vertically or horizontally column by column from top to bottom and left to right. At each slide local quality index is evaluated to measure the statistical feature at local evaluation point and combine all to obtain the global Quality Index.
There is sliding window concept used to combine all local quality analysis. Let there are total M step, then combined quality index given

$$Q = \frac{1}{M}\sum_{j=1}^{M} Q_j \qquad (12)$$

Our Test include different corruption like additive Gaussian noise, impulsive salt-pepper noise by contrast stretching and mean shift including blurring and JPEG compression.

1.10 PERFORMANCE MATRIX

To measure the performance of any method there are a lot of technique and algorithm some very important out of them discussed here.

1.10.1 ABSOLUTE MEAN BRIGHTNESS ERROR (AMBE)

As its name says it is the difference between the mean brightness of the input image and output image, It is always positive because absolute value taken.

$$AMBE\ (I, O) = |M[I] - M[O]| \qquad (13)$$

Where, M(X) is the mean intensity of image X. lower value of the AMBE, implies more brightness preserved by the enhancement technique, means lesser the value of AMBE better is the brightness preservation and hence more powerful brightness preserving technique. M(X) defined for an test image

$$M(X) = \left\lfloor \sum_{K=Xl}^{XU} X_K * p(X_K) \right\rfloor \qquad (14)$$

1.10.2 DISCRETE ENTROPY (DE)

DE shows how much information an image contain. More value of DE means more information test image have. More DE implies lesser intensity saturation, hence to check intensity saturation preservation need to evaluate the DE[14]. And DE can be evaluate as

$$DE = -\sum_{k=0}^{L-1} p(X_K) * \log_2 pdf(X_K)(bits) \qquad (15)$$

Where $pdf(X_i)$ is the probability density distribution of i^{th} intensity level. Pdf can be evaluate very easily from histogram.

1.10.3 STANDARD DEVIATION(SD)

Contrast of an image is measured as standard deviation and represent by σ .and defined as.

$$SD = \sigma = \sqrt{\sum_{K=0}^{L-1}(X_K - m)^2 * p(X_K)} \quad (16)$$

Where, m represent the mean intensity of the image. So from this it is know that higher value of σ implies more contrast preservation. But this is also fact that higher value of σ does not mean better contrast enhancement always.

1.10.4 EDGE BASED CONTRAST MEASUREMENT (EBCM)

The edge based contrast measurement (EBCM) is also a parameter to measure the contrast enhanced of an image. This is derived from the fact that human observation and noticing perception is more on the edge [16]. The EBCM of an image I having dimension U*V; defined as:

$$\mathrm{EBCM(I)} = \sum_{i=1}^{u}\sum_{j=1}^{v}\frac{c(i,j)}{u*v} \quad (17)$$

Where C(i, j) represent the contrast of pixel(i, j) and its intensity represent by I(i, j) hence it is defined by:-

$$C(i,j) = \frac{|I(i,j)-e(i,j)|}{|I(i,j)+e(i,j)|} \quad (18)$$

In equ.(18). e(i, j) measure the edge gray level defined as….

$$e(i,j) = \sum_{(y,z)\epsilon\, \alpha(i,j)} g(y,z)I(y,z) \,/\big(\sum_{(y,z)\epsilon\, \alpha(i,j)} g(y,z)\big) \quad (19)$$

α(i, j) represent all the neighboring pixels of a pixel (*i, j*), and *g*(*y, z)* represent the edge value of the pixel (*y, z*), where it represent the magnitude of the image gradient using Sobel operators.

Without losing any generality of image, a 3× 3 neighborhood matrix is used. It can be seen experimentally that for an test image O of the input image I higher the value of EBCM(O) higher the contrast improved in most of the cases, that's why EBCM always does not mean image got enhanced hence always a set of all quality index parameter is used to measure the image enhancement value.

1.10.5 UNIVERSAL IMAGE QUALITY (UID)

To measure the preservation of "natural appearance" of input image I universal image quality (UIQ) is used for histogram Equalization [16]. For defining the UIQ, let I ={I_k,k=1,2,3,4,……..,N} and output image O = {O_k , k = 1, 2,3,4,……..., N} are symbolic representation for input image and processed image, each of same dimension Size= m × n, so UIQ is written as

$$UIQ = \frac{4\sigma_{IO} \times m(I) \times m(O)}{(\sigma_I^2 + \sigma_O^2)[(m(I))^2 + (m(O))^2]} \tag{20}$$

As previously explained m(I) and m(O), define the mean intensity of input and output images. Where σ_I^2 , σ_O^2 , σ_{IO}^2 are defined below;

$$\sigma_I^2 = \frac{1}{N-1} \sum_{i=1}^{N}(I_i - m(I))^2 \tag{21}$$

$$\sigma_O^2 = \frac{1}{N-1} \sum_{i=1}^{N}(O_i - m(O))^2 \tag{22}$$

These parameter are same previously defined all three types of distortions; luminance distortion, loss of correlation, and contrast distortion. So UIQ more nearer to unity more natural appearance preserved by equalization process. Hence this is better parameter to measure the natural appearance than previous one.

1.10.6 PEAK SIGNAL RATIO

For electronic product to get the appropriateness of processed image, the quality of output image measured from the Peak Signal to Noise Ratio (PSNR) [14], defined in equ.(23)-

$$\text{PSNR} = 10\log_{10}\left[\frac{(L-1)^2}{MSE}\right] \tag{23}$$

MSE is the mean square error that can be evaluated from equation (24)

$$MSE = \sum_i \sum_j |I(i,j) - O(i,j)|^2 / N \tag{24}$$

I (i, j) represent the (i,j) pixel intensity and O (i, j) corresponding to the output image intensity respectively, and Total number of pixel of the image represent by N.

1.10.7 IMAGE QUALITY MEASURE (IQM) RATING(R)

This technique measure the quality of image in term of human opinion. Because texture and luminance masking affect the visibility of human being. It Image Quality Measure Rating (R) is used for evaluating the subjective quality of the processed images. Actually what it measure, it measure the total noise pixel present in output image to the total number of pixel in image. That's why IQM is used when we want correlate the image quality with human perception [17]. Here R represent the ratio of total number of pixels having noise (I_{noise}) and N is the total Number of pixel in test image.

$$R = \sum_{i=0}^{u-1} \sum_{j=0}^{v-1} I_{noise}(i,j)/N \tag{25}$$

So, $I_{noise}(i, j)$ highly dependent on edge magnitude and local entropy of the processed image and original images. To evaluate the performance of different type of HE methods using R, need to extract the edge magnitude and local entropy by a number of parameter. These values already explained in previous performance matrix in section the values of local entropy and edge magnitude have been extracted using the set of parameters. It says that smaller the R, more quality perception of image as user view.

1.10.8 MEAN STRUCTURAL SIMILARITY INDEX

Structural similarity index (SSI) to measure the Image quality find using eq.(27) [12]:

$$SSI(x,y) = \frac{(2\mu_x \ \mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (27)$$

Where μ_x and μ_y are the mean of image X and Y, σ_x and σ_y represent the standard deviation of image X and Y respectively, σ_{xy} is the square root of covariance of the image X and Y, whereas C_1 and C_2 are constants. The mean SSI is.

$$MSSI(x,y) = \frac{1}{M} \sum_{i=1}^{M} SSI(x_i, y_i) \quad (28)$$

Where X and Y are the input image and the test image, respectively. x_i and y_i are the content of the i^{th} local window of input image; and where M represent the total number of local window.

1.10.9 CONTRAST PER PIXEL

To measure the average intensity Contrast per pixel (CPP) is used [9], and what is CPP, it is the difference in the intensity of two adjacent pixels. This give the local contrast of test and input image.

$$C = \frac{\sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \left(\sum_{(m,n) \epsilon R_3^{(i,j)}} | \gamma(i,j) - \gamma(m,n) | \right)}{M \times N \times 8} \quad (29)$$

1.11 NORMALIZATION OF MEAN BRIGHTNESS

Normalization of mean brightness is used to bring the over-brighten output image to the mean brightness of the input image (M_i).v and M_0 is the calculated mean brightness of the output image or test image [9]. Brightness normalization done using equation(30)…

$$g(x, y) = (M_i / M_o) f(x, y) \quad (30)$$

Where g(x, y) represent the output image after normalization, and f(x,y) shows the output image that is produced by Histogram equalization process. Because of this output image brightness is closer to the input image brightness image.

CHAPTER 2

LITERATURE REVIEW

Image enhancement is very challenging task because of it need to work on each pixel. During enhancement we have to process each pixel of image many times. Hence processing complexity increased with the size of image. So we have to type of devices, one is small hand hold or low processing power devices for such devices we need to consider the complexity of algorithm along with how much enhancement given by that algorithm. Another powerful devices that are used to process the large images like satellite images, in this case our main focus is on getting maximum enhancement, we can accept high complexity of algorithm because of powerful machine. Image enhancement work on image as it arrives for display like in tv when a frame arrive it should be processed very fast without any delay and displayed on screen a enhanced version of image or frame. Image is a grid of pixels where pixel is the smallest unit of picture element that is displayed on any digital display device like television screen, computer monitor etc. and has a specific height and width. Every pixel has a settled down size on a given plane. A Digital Image has two dimensional shape which represents grey level also called pixels and are collectively called image or a two dimensional image represented in binary form known as binary image. 2D image has only two dimensional structures (X-axes and y-axes) on a given plane OR it is an image which has only x and y coordinates [1]. 3D image is constructed with three coordinates (x, y and z) axes. Some preprocessing is required to obtain 3D view of an image from the 2D image. Digital image processing (DIP) is a series of operations that are applied to an image and as a result the image has more visual properties. Image processing system has three main elements i.e.

1.) Acquisition of Image
2.) Processing of image
3.) Displaying the Image

There are three main levels of processing in DIP i.e., low, middle and high level. Operations included in low level are image sharpening, image enhancement and reducing noise from the image. In fact, the inputs and outputs of images are in the form of low level of image processing. Middle level operations are normally image segmentation image recognition, reconstruction and rendering etc. Inputs of this level are normally images but outputs of the process is the feature extracted from the images during process. The higher and last level of image processing is analyzing the image.

Contrast Enhancement: Images which have a more grey level are considered as good contrast images. The fundamental purpose of the image enhancement to visualize the hidden object or information in the object that is not visible to human eye. Because we are not able to detect very small difference in pixel intensity. Hence using HE we increase the relatively difference in the pixel of image. An image with a good contrast has automatically an excellent quality but it is not normally ideal due to several reasons such as noisy environment, poor lighting effects and failure of capturing device etc. An example of contrast enhancement is shown in where contrast is increased and noise is removed from the image which automatically provides visibility

2.1 HISTOGRAM SPECIFICATION (HS)

Histogram specification is a contrast enhancement technique in which we have a target histogram. We change the low contrast image histogram into a high contrast image histogram by mapping pixel intensity of input image using a function into pixel intensity of target images histogram. It is used when we have different images of same scene taken at different time and in different environment by combing all those image we got best image have all good feature from all those images combined in one image. However it always does not give best result but if we combine HS with other Histogram technique a significant improvement in image be there.

2.2 HISTOGRAM EQUALIZATION (HE)

Histogram Equalization is the most easy and common technique, for contrast enhancement of the image. It is easy to apply because it need only to calculate the histogram of image and then applying some algorithm on the histogram to uniformly distributes the pixel of image over all gray level of the original image histogram as a result of which a good contrast enhanced image is obtained. Histogram equalization is used in several fields as an enhancing technique such as voice recognition system, texture analysis and medical image processing [2]. Histogram Equalization (HE) fundamental function is to enhance and increase the grey level of image but this technique has some drawbacks as well e.g., it assigns one grey level to two nearest grey levels with different strength and secondly it has the washout effects if it assigns grey level to the higher intensity which affects its performance. To improve the efficiency of HE, many techniques have been suggested by researcher to preserve the background brightness of the input image using histogram equalization and need to preserve the background image brightness . In HE, image histogram is divided into different levels and each level is enhanced individually. This method preserve the image background brightness and overall enhancing the image contrast. A mean brightness preserving method which also removes the noise present in the image. Hence it make overall histogram of image smooth and then can be decomposed into several segments by using specific threshold value after which each segment is enhanced individually. In Gaussian mixture model was presented which dispersed the input image grey level and the crossing point of that model was used to divide the range of image level so that an equalized image is obtained by changing the input image grey level interval into proper output image grey level interval. This Gaussian mixture model algorithm is also called automatic image enhancement technique because, the non-linear image mapping is applied on the input image for creating equalized image. Other HE techniques such as object based and dynamic range based techniques are especially for consumer use and have a less computational time. A method for reducing noise from an image and a resonance technique for the low contrast images is proposed [14] whose performance is superior to other existing techniques without any color loss. Hence to improve the contrast of the image, weighted histogram equalization method is used for better result than HE. This method provides a reasonable image quality as a result and its hardware implementation is easy. A technique is introduced which is applied to graphical information of the input image. NOSHP (Non-overlapped Sub-blocks and Local Histogram Projection) is presented in which provide pleasant visual effects in the image also used in real time systems. A method is presented in which enhanced different grey levels of the input image, it can be seen that single grey levels have edge information present in the image . In piecewise linear approximation of cumulative distribution function has been described and limited adaptive enhancement technique has been proposed in to enhance local details of the image. Global histogram equalization is one of the simplest methods concerned only with global features of the image. This technique gets failed in a situation where we are only interested in local information of the image.

2.3 BRIGHTNESS PRESERVING BI-HISTOGRAM EQUALIZATION (BBHE)

This technique was discovered in 1997 who remove the drawback of the Histogram equalization. BBHE takes one image as input and splits it into two sub-images based on the mean as a threshold value [4]. The first part of sub image contains the pixels whose values are less than or equal to mean and the second part have the remaining pixel or all pixel whose intensity value greater than mean of the input image. In this method the input mean presents the mean intensity of all pixels of an image having histogram range from 0 to L-1. The first histogram contains pixels whose value lies within [0, mean] and second histogram contain the pixel whose value in range [mean+1, 255] in case of gray image. BBHE is applied to both sub image independently after which both equalized images are combined. BBHE can enhance any input image and used for the consumer electronic while preserving the mean brightness

2.4 DUALISTIC SUB-IMAGE HISTOGRAM EQUALIZATION (DSIHE)

It is improved contrast enhancement technique than BBHE but in this technique the image is segmented into two parts based on the median value of image instead of the mean grey level after which both sub images are equalized and then combined to have equal area dualistic sub image HE [7]. In this technique the division of image is for the purpose of maximizing the entropy according to the resultant image. Hence input image is divided into part based on median, that's why both sub-image have equal number of pixel can say one is dark pixel and other are bright. The resultant image obtained by DSIHE is average of the input image [22]. There is not any visible change in the brightness of input image and output image according to the authors. This technique not only efficiently enhances the image but keeps its originality as well. Because of its partition process both histogram segment have large number of pixel both have tendency to improve the contrast. Lower histogram portion dominate the dark value pixel or black in output image by shifting the pixel values toward zero. And second or upper histogram segment contribute the whiteness to the output image. Because both sub-histogram have same number of pixel, hence brightness and black factor increased in same proportion. This the reason it is better than BBHE in case of brightness preserving. So this technique is good when most of image portion covered by background portion of the image. It avoid the over enhancement of the background portion which avoid the losing of foreground object in the influence of background pixel value.

2.5 MINIMUM MEAN BRIGHTNESS ERROR BI-HISTOGRAM EQUALIZATION (MMBEBHE)

MMBEBHE is the improved form of BBHE and it also split the image into sub-images using threshold value [11]. The core difference between BBHE, DSIHE and MMBEBHE is the selection of threshold value that decomposes the input image into two parts-1 [0 to th] and part-2 [th+1 to L-1] for obtaining the minimum brightness. This method is defined by the following three steps. First mean brightness is calculated. Secondly, the selection of proper threshold is done on the basis of AMBE. Finally, it splits the input image histogram into two parts using minimum AMBE as threshold value. And equalize the sub-images independently. This method is efficiently applicable for real time applications, because it preserve the AMBE that give good picture quality in electronic display the effectiveness of this method based on the fact that it uses AMBE as a threshold value for segmentation.

2.6 RECURSIVE MEAN-SEPARATE HISTOGRAM EQUALIZATION (RMSHE)

It is an extended form of BBHE which recursively decomposes the given image up to r and 2^r sub parts after which each sub image is enhanced independently [8]. When r=0 this means that there is no sub image. This technique not only preserves the brightness but also effectively enhances the image. In this technique more brightness is required in order to separate its final histogram based on its recursive mean. RSIHE (Recursive Sub-image Histogram Equalization) has a drawback of multiple decompositions Mean Brightness Preserving Histogram Equalization (MBPHE) Basically MBPHE method can be classified into two parts; bisection MBPHE and multi section MBPHE. The bisection method simply divides the input histogram into two parts and equalizes them independently. This method can preserve the mean in some cases when the input histogram is uniformly distributed around its division origin. But this property is considered as a failure because every histogram can have this property. Splitting the input image histogram into two parts is not sufficient for preserving the mean brightness. So the concept of separating the input image histogram into more than two part. In multi section MBPHE the input histogram can be divided into more than one part and can equalize them independently. In this technique the sub image histogram is equalized by taking median or mean value recursively and has a good result as compared to the bisection method. Its hardware implementation is complicated and much computational time is required for consumer electronic. Processing time can be reduced by using parallel processing on each segment, but parallel processing not available in all electronic devices.

2.7 BRIGHTNESS PRESERVING DYNAMIC HISTOGRAM EQUALIZATION (BPDHE)

This technique researched to overcome the weaknesses of HE. It produces the resultant image having mean intensity equals to the mean intensity of input image. In BPDHE technique Gaussian Filter is applied on the input histogram which makes it smooth and then on the basis of its local maximum the smoothed histogram is separated in parts after which dynamic range is assigned to it [10]. Finally each partition is equalized through equalization process. The weaknesses of this technique are removed in by using BPDFHE (Brightness Preserving Dynamic Fuzzy Histogram Equalization). Problem of choosing automatically number of segmentation, the number of segment should be there in image enhancement technique decided on these factor are major key point in the research.

1) Contrast enhancement;

2) Brightness preserving;

3) Natural appearance.

All these three major key factor can’t be satisfied together. Based on the purpose of image enhancement need to neglect some kay factor. As we know contrast improvement and natural appearance preservation both are on the opposite bank of a river. Means both can’t be satisfied together we have to compromise one of them. If we increase the number of segment contrast improvement decreased but natural appearance saved up to maximum level. Brightness preserving factor can be saved with both contrast enhancement and natural appearance preservation. Need to consider the cost of increasing the number of segment. Because if processing of algorithm is too high then it is not possible to apply it in real time electronic devices such as mobile display and TV display. In this technique our main focus on brightness preservation, so we normalize the output image to get back the intensity value difference according to input image pixel difference with their neighbor. Normalization technique already discussed in Introduction part of the thesis. If you need to read more on normalization you can consult [16].

2.8 DYNAMIC HISTOGRAM EQUALIZATION (DHE)

Dynamic histogram equalization is also HE, but range for the each segment is not according to input histogram segment but depend on the number of pixel in a sub-segment and difference between the highest and lowest intensity value in that sub-segment. DHE partition the image histogram into a number of sub histogram parts and then the dynamic grey level ranges are allocated to each part [23]. This can prevent washout out effect of the input image and also presents moderate of the input image. Basically this technique has three main steps; division of input histogram, allocating ranges and finally applying the HE on each sub part of histogram. Using DHE output image mean intensity equal to the input image intensity. And brightness of the image preserved using the normalization concept. If we talk about step involved in the DHE. Firstly image is segmented into a number of segment based on the processing power of the device. Now if the histogram shape is smooth then DHE give same result as recursive image segmentation, but if histogram not smooth and distribution of pixel is highly non-liner on histogram. In this case DHE really helpful to avoid the uneven expansion of the intensity. Sub-histogram having more number of pixel in small range of intensity level expanded to the full gray level as shown in fig.(8).this help to expand those important pixel over full grey level range. So that object consist of those pixel got contrast enhanced and become visible to the human perception view. This will happen for all major object having dark pixel or displayed over a very small range of intensity in the image. For some images it unnecessary increase the brightness of the image, to avoid this no need to expand those narrow ranged sub-histogram over full range of grey level, instead use another formula that compare the relative wideness of other sub-histogram and who have narrow among all histogram, only expanded to some range.

2.9 MULTILEVEL COMPONENT BASED HISTOGRAM EQUALIZATION (MCBHE)

It segment the input image into two or more segment known as background and foreground sub images. The multi grey level of each sub image is processed and its component is analyzed just like handwritten recognition, components are identified which are below or above each threshold value. As the threshold level changes, it is able to capture the image grey level variation. This technique is efficiently used for enhancing local detail of the image. The MCBHE algorithm starts with segmenting the image based on original mean brightness. And these sub-images called background and foreground sub-images. Unlike other HE it uses connected component based on the multi threshold it find the connection between the components, who are obtain by further segmenting the image. Then improve the each segment individually. After locally improving the component global HE is applied [24, 25]. Also extract the local feature of object to improve overall contrast by analyzing those local feature of object in image.

2.10 ADAPTIVE CONTRAST ENHANCEMENT METHODS WITH BRIGHTNESS PRESERVING

This technique have a lot of improvement over previous discussed technique. This also work like histogram equalization. We divide the histogram into two or more sub-histogram. Then each sub-histogram is analyzed and clipping take place on individual sub-histogram. Clipping is done to smooth the histogram so that more number of pixel with same intensity does not suppress the contrast of lower valued histogram pixel. Here we have the choice to redistribute the clipped histogram over sub-segment. After clipping each sub-histogram is checked whether it is a narrow segment or not. If it is then this segment is expanding and all sub-segment equalized separately. Next step is to normalize the whole histogram to avoid intensity saturation. Normalization process bring all the pixel value to original pixel value.

2.11 CONTRAST STRETCHING RECURSIVELY SEPARATED HISTOGRAM EQUALIZATION (CSRSHE)

The main objective of this algorithm is to enhance the contrast and preserve the brightness of the image. In CSRSHE technique input image is analyzed and a new grey level is assigned to both local and global pixels of that image. Secondly, the histogram is separated in sub parts recursively using the mean intensity of image and every sub-segment equalized independently [28].

2.12 CONTRAST ENHANCEMENT USING BI-HISTOGRAM EQUALIZATION WITH NEIGHBORHOOD METRIC (BHENM)

Main focus on this algorithm to improve the local contrast of the image and save the image brightness. And it avoid over-brightness of the image because it uses neighborhood matrix for local improvement of contrast. To avoid the saturation because of large bins size, clipping applied. Benefits of using neighborhood matrix it preserve the local mean intensity and improve the contrast according to local processing matrix [29].It is an extended form of BBHE known as BHENM. It enhances the image contrast while preserving its brightness. This new technique has two stages; first the histogram bins are divided into sub bins and secondly mean is taken to divide the original image histogram in two parts. Then each part is enhanced through BHENM. We discuss lot of technique to improve contrast of an input image by histogram equalization technique. Most of the technique uses division a histogram into sub-histogram and performing HE on each individuals. These result into improved contrast while losing other properties like natural appearance and over-enhancement of some part of image who reduce the enhancement of small portion of an image. We can agree on the fact that all property of an image can not be enhanced at once or using only single technique. We can apply different technique in serial order to achieve overall enhancement of image, while not losing natural appearance of image and mean brightness.

CHAPTER 3

PROPOSED WORK

We discuss a lot about HE technique, by analyzing all these technique we try to find out a new way of enhancing the contrast of image. Our Method work fine for dark images and give good contrast enhancement. We divide the image into 4- segment that contain equal number of pixel. It is not necessary to divide the image into 4- segment, it may be less or more depending on the complexity you want for your algorithm. Or we can say segmentation of image take place based on equal number of pixel in sub- segment.

Then we see whether there is need to applying histogram clipping or not. If it is apply the histogram clipping by using median value of non-empty bins. Histogram clipping applied on each segment separately. Because each segment have their own set of histogram bins, it depends on the structure of sub-histogram whether there is a need of clipping on that sub-histogram or not. We use threshold value for clipping is median, because it reduce the calculation complexity that is there in case of plateau algorithm for finding the clipping threshold. And another advantage of using median over plateau method that it fail for some images. Our main focus not only contrast improvement but also maintain the mean brightness. We also focus on maintaining the natural appearance of the image. As we know that number of number of segment increases lead to decrease in the contrast enhancement. Dynamic range allocation to each segment, if a segment is narrow it is expanded in full gray sca1e [0 255]. If not then expanded only within its range.

Formula used for segmenting the histogram:

$$mean_1 = 0.25 \times \{I_h \; * I_w\} \tag{34}$$

$$mean_2 = 0.50 \times \{I_h \; * I_w\} \tag{35}$$

$$mean_3 = 0.75 \times \{I_h \; * I_w\} \tag{36}$$

Where m_1, m_2, and m_3 are intensities set of containing 0.25 pixel of image, 0.50 pixel of image and 0.75 pixel out of total pixel of image. Hence these equation work like segmenting the image based on the median. Here we can also divide the image into more segment if we wish.

Clipping process applied on each segment to avoid the over enhancement of HE. You can use any clipping method discussed earlier, but we use median of non-empty bins, because it is easy to implement and not have the complexity of algorithm too much. In our proposed method we redistribute the clipped portion of histogram equally.

New range allocation:

$$span_i = m_{i+1} - m_i \tag{37}$$

$$range_i = (L-1) \times \frac{span_i}{\sum_{k=1}^{4} span_k} \tag{38}$$

In the i^th sub histogram new range is allocated from [i_{start} i_{end}] defined as:

$$i_{start} = (i-1)_{end} + 1 \tag{39}$$

$$i_{end} = i_{start} + range_i \tag{40}$$

Histogram Equalization:

$$y(x) = (i_{start} - i_{end}) \times cdf(X_k) + i_{start} \tag{41}$$

Normalization on image:

For normalization we find the mean brightness of our input image is $mean_i$ and the mean brightness of the output image is $mean_0$ is calculated using given formulas. To shift back the mean brightness to the original image ($mean_i$). Normalization of the Brightness of input image is calculated as…

$$h(i, j) = (mean_i / mean_o) f(i, j) \tag{42}$$

Where h(i, j) is the output image, and f(i, j) is the output of the histogram equalized image. Normalization process will bring the brightness of the output image nearer to the brightness of the input image.

CHAPTER 4

EVALUATION, AND RESULT

We need to test our algorithm, for that we uses some images having more dark pixel. Means object are not visible properly because of poor contrast or image taken in less light. Then we apply our algorithm and result for images shown below. As we can see it shows far better result than traditional HE and Bi-HE. In most of images improvement of contrast is really good. But in some image it is less but in that case natural appearance of image is maintained.


Fig.12 (a)


Fig.12 (b)


Fig12 .(c)


Fig.12(d)


Fig.12 (e)


Fig.12 (f)

Where Fig12.(a, b, c) are original input image taken during less night or dim light. That's why objects are not clear, where as Fig12.(d, e, f) are corresponding enhance images.

Fig.12 (g)

Fig.12 (h)

Fig.12 (i)

Fig.12 (j)

Fig.12 (k)

Fig.12 (l)

Also Fig.12 (g,h,i) are input images and Fig.12 (j,k,l) are the corresponding enhanced images. It can be seen image (g) taken during earlier morning, hence having poor contrast which is enhanced in image (j). Image (h) represent an Art which is too dark, when we enhance this image we got all hidden object in image (k).

All images shown here are of big size (1024 *765), Here they are shown in small size that's why all portion not visible. You can got those images from soft copy of my thesis submitted in department.

QUALITATIVE ANALYSIS OF VARIOUS IMAGES

AMBE (ABSOLUTE MEAN BRIGHTNESS ERROR)

Algorithm ↓	**Figure →**	**Fig. A**	**Fig. B**	**Fig C**
HE		20.38	30.23	18.86
BI-HE		15.33	12.45	15.34
Proposed method		8.26	6.23	2.15

Table 1- AMBE value for HE, BI-HE, and proposed algorithm

PSNR(PEAK SIGNAL TO NOISE RATIO):-

Algorithm ↓	**Figure →**	**Fig. A**	**Fig. B**	**Fig C**
HE		10.43	5.82	18.86
BI-HE		12.89	9.57	25.14
Proposed method		20.36	19.28	30.74

Table 2- PSNR value of images for HE, BI-HE, proposed algorithm

CHAPTER 5

CONCLUSION AND FUTURE WORK

We can conclude from above result that we can to improve the contrast of image but loss the natural appearance of that image in some cases. Hence in we need to focus on to maintain the natural appearance of the image, in case of a human image, to make look more realistic. Here we are segmenting the image into equal number of pixel we need to do more experiment that how can I segment the image so that natural appearance does not loss. For segmenting the image we can consider the local and global intensity of pixel inside a specific region of image that need to be focused. And we know that normalization is mainly used for removing over brightness, in case of dynamic expanded range for sub-histogram is used. Need to focus on normalizing technique. Normalization technique depends on how we segment a image according to that we finalize our normalization technique.

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