IMPROVED AUTOMATIC IMAGE ENHANCEMENT TECHNIQUE

By

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ABSTRACT

Images play a vital role in scientific research. The images which we capture are different in nature, few images are bad in quality because of bad circumstances like bad lightening, undesirable conditions, error in capturing device itself etc. contrast enhancement plays an important role for better visualization, to get suitable results and for the improvement of quality of image.

In this thesis we proposed a technique for the contrast enhancement of both types of images the color images as well as gray scale images. The proposed method calculate two parameters statistics and phase congruency of the image. Furthermore we use optimal histogram method which is RIQMC based and histogram equalization which is non parametric is used to perform the contrast enhancement. Added to this, we presented two methodologies, purpose of one is the brightness of the image remain preserve and other is used to adaptively increase its brightness.

Subjective comparison is performed by considering the improved contrast and absence of useless artifacts. Analyses of the contrast enhancement images are also perform by the quantitative measure. Simulation results on the different images conclude the significance of our proposed model.

DEDICATION

This thesis is dedicated to

MY BELOVED PARENTS, BROTHERS, SISTER,

HONORABLE TEACHERS AND FRIENDS

for their love, endless support and encouragement

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ACRONYMS

- FR: Full Reference
- IQA: Image Quality Assessment
- NR: No Reference
- RF: Reduce Reference
- HMF: Histogram Modification Framework
- HE: Histogram Equalization
- WTHE: Weighted Threshold Histogram Equalization
- AMBE: Absolute mean brightness error
- JPEG: Joint Photographic Expert Group
- OCTM: OPTIMAL CONTRAST-TONE MAPPING
- BBHE: Brightness Bi-Histogram Equalization (BBHE)
- DSIHE: Dualistic Sub Image Histogram Equalization
- RMSHE: Recursive Mean Separate Histogram Equalization
- SSIM: Structural Similarity Index
- MSE: Mean Square Error
- PSNR: peak signal,-to-noise ratio
- MSE: The mean square error
- SNR: noise ratio signal-to-noise, ratio
- AGCWD:Adaptive Gamma Correction with Weighting Distribution
- PC: phase congruency
- NCC: Normalized Cross Correlation
- RIQMC: Reduced reference Image Quality Metric for Contrast change
- ROHIM: RIQMC Based optimal histogram mapping

- NMHE: Non parametric modified histogram equalization for contrast enhancement
- M_u = Measure of Un-equalization

Chapter 1

INTRODUCTION

Image enhancement commonly used in computer applications. It is the type and sub area of image processing. Image enhancement has a key role for betterment of the quality of image and its main objectives and the principle is to make the result of an image more suitable by applying appropriate techniques on the input image. We can improve the quality of image by doing analysis of different images, we can brighten the image and the noise in that image can be removed by applying these steps to the image to identify the key features of an image easily. Few applications of image enhancement are discussed below.

1. Multimedia: Image enhancement techniques has delivered exciting results in multimedia field. These techniques efficiently exchanging image data and extracting the useful knowledge, and hence it increases the system capabilities. These are used for improving the value of image and video data.

2. Remote sensing: Normally the original brightness values of an image that were recorded by the instrument are important to use. However, most data which is remotely sensed is viewed on a computer display. Sometimes it is often desirable to make changes to the visual appearance of the imagery. Different types of image enhancement are very helpful here to improve the interpretation in an image by a human being. Image enhancement is also useful for image analyst to employ image enhancement for understanding or discovering the contents of the image.

3. Security and Surveillance: Arial imaging is a way to obtain information from the earth surface. This is a common and versatile way of obtaining information. The images are captured from artifacts or satellites with some altitude having range

Figure 1.1: Contrast enhancement

from hundreds meters to hundreds of kilometers. The higher and wide angle lenses increases the view area and hence it reduces the resolution. The poor weather conditions, limited dynamic range of camera and signal to noise ratio due to the thermal characteristics of electronics device, results in aerial images. So the idea behind enhancement techniques aim to match the recorded image to the observed image bringing out details that are otherwise too dim to perceived due to insufficient brightness and contrast.

4. Medical Imaging: Medical imaging is the enormous source of information and core of medical science that need to be utilized. Image enhancement techniques with regards to biomedical images are generally either used for the retrieval of images which is content based image retrieval or for analysis and modification of images. Medical imaging technologies play important role not only in the diagnosis and treatment of diseases, but also in disease prevention, health checkup, health management, early diagnosis and rehabilitation.

Different methods for enhancement and the visual interpretation of the images, that there is no common theory of enhancement of different images. Therefore some authors proposed the different methods and techniques for image enhancement. These techniques are useful for better look of the image.

1.1 Common artifacts

1.1.1 Blur

In all imaging processes like vision and photography blurring artifact is present. An image is basically a visual representation of specific physical object. Within the object each small point represented by well-defined point with in the image. Blurring occurs when image of each object spread with in the image. Blur Size in an image is the amount of blurring can be expressed as the blurred image dimension of a very small object point. Blur Shape is the blur of an image can have a variety of shapes. These shapes are depends on the blur source. Image intensifier and intensifying screens produces round blur patterns. Most of the imaging methods which produces digital images produces the 3D or square blur pattern. Blur profile is depends on the intensity distribution. This intensity distribution is related to spreading of point image with in the blur area. Actual distribution of an image is basically the mean of an intensity profile. Some sources are distributed uniformly the object point image intensity with in the blur area. Un-sharpness in an image which has distinct boundaries and much detail is described as being sharp. Un-sharpness is produced due to presence of blur in an image. Image un-sharpness is referred as several visual effects due to the basic process of blurring.

1.1.2 Resolution

The term resolution is often considered to pixel count in an image, it should instead be called in international standards as " number of total pixels" and as "number of recorded pixels". So we can say that resolving ability of an image is basically the method to evaluate the system blur and it depends on distribution of blur within the system. For example a typical curve which is associated with focal spot blur has a specific point at which contrast become zero. This is referred to as disappearance frequency and represents the resolution limits. An image of N pixels height by M pixels wide have any resolution , but when the pixels counts are referred to as "resolution" with set of two positive integer numbers for example as 7680x6876. which can be calculated by multiplying pixel columns by pixel rows and dividing by one million.

1.1.3 Noise

Noise is the abrupt change in visualization of image or changes information of color in image also referred as unwanted signal. Noise occurs in an image due to camera captured more light or heat camera sensor. In digital cameras noise can be measured through random speckles whereas in analogue cameras grainy specs are used to show image noise. Different types of noise in an image are shot noise, Gaussian noise, salt and pepper noise, quantization noise and non isotropic noise.

1.1.4 Reflection

The issue of reflection arises naturally when a desired scene contains another scene reflected by another medium which is transparent or semi reflective medium. Photographs captured through windows or taking images of those objects which are placed inside the glass are the common examples of reflection. Reflection will happen when properties of the lens or the position of the camera relative to the subject. Reflection will happen when between two different media variation in direction of wave front at an interface so that the wave front returns into medium from which it originated. In reflection the angle which is incident on the surface is equal to angle which is incident on the surface.

1.1.5 Contrast

Contrast can be explained as the difference minimum and maximum pixel intensity in an image. Contrast in an image is highly concentrated on a specific range. The factor contrast impact on complete image for example if an image is very dark, its mean the information may be lost in those areas which are uniformly concentrated. So to solve this issue, this problem is to optimize the contrast of an image. The optimization process is used here in order to represent all the information in the input image.

In this thesis contrast enhancement using different techniques will be discussed in details. Also the state of the art techniques will be discussed. Contrast is an important factor as compare to other artifacts because we can perceive the world similarity regardless of the huge changes in the image. Contrast is an important factor in evaluation of image quality. Contrast enhancement improves perceptibility of objects by enhancing the brightness between object and their backgrounds. Typically contrast enhancement performed as a tonal enhancement and contrast stretch, although these could both be performed in one step for the enhancement of contrast. Contrast stretch improves the brightness factor highlights (bright) or high contrast inside the dynamic range of the image, whereas tonal factor give information about shadow (dark), mid-tone (grays), or low contrast regions at the expense of the brightness difference in the other regions. A high contrast image spans the values of full range gray levels. Stretching is a phenomenon which is used to remap the low contrast image into high contrast image. Contrast stretch is referred as dynamic range adjustment, in this the lowest value (low contrast) maps to zero and highest value (high contrast) maps to 255 for an eight bit image, all other gray levels remapped between 0 and 255.

1.2 Problem Statement

General issues in existing enhancement techniques i.e after enhancement the image details are degraded. Luminance and contrast is equal for every pixel, but illumination all over the images has not been same, some rergions may be bright and some may be dark. Images may pass several stages before being presented to a human observer. Digital image capture by digital camera and other devices that send to the processor for further process just like the HVS is captured by sights and is sent to the brain for further process. The distortions may be into the signals which send to the brain due to problems in NSS and visual system, causes problems at any stage of processing in HVS. Same as each stage of digital image processing introduce distortion that disturb the quality of image. Modifying the attributes of an image is the focal objective of enhancement of image. The purpose of modifying attributes of an image for a given task is to make it more appropriate. Sometimes we modified just single attribute of an image for a particular purpose and a task, and sometimes modified more features for multipurpose tasks. The selection of these features and its modification process is specific. Moreover there are some factors which are related to the observer are known as the observer-factors, like observers experience and the visualization of human system. For color images and gray scale images, based on different attributes, different enhancement techniques are used to found the best enhancement method for different types of images.

Basic limitation of the existing techniques has certain artifacts like they cannot at the same time improves all parts of the image very well and it is difficult to automate the image improvement procedure. The main problem in previous techniques is that, after enhancement the image detail are ruined.

1.3 Contribution

The contribution in this thesis is summarized below.

- An efficient technique that improves the accuracy and efficiency of image quality assessment measure.
- Using higher order statistics and the entropy of images to develop better quality.
- Using reduced reference image quality metric for contrast change (RIQMC) and derive improved RIQMC based optimal histogram mapping (ROHIM) model.

1.4 Thesis Outline

The thesis is organized as under.

- Chapter2: This chapter includes the literature review and background along with brief description of existing techniques. It includes frequency domain and spatial domain which are two basic types of imge enhancement techniques. Qualitative attributes of an image are Peak signal to noise ratio $(PSNR)$, Mean Square Error (MSE), Least Mean Square Error $(LMSE)$, and normalized cross correlation. These attributes of an image are described in chapter 2, that how to calculate these terms. There are also some problems which are non linear, so types of non linear least square problems are briefly discussed in this portion of the thesis.
- Chapter 3: Proposed method, design methodology includes in this chapter. Proposed model is comprised in RIQMC model, ROHIM model and Non Parametric histogram equalization NMHE. In RIQMC model we calculate the mean shifting function, logistic function and NMHE Model we calculate clipped histogram and measure of unequalization.

- Chapter 4: Result and analysis, Quantitative measure and the qualitative measure are discussed in this chapter. In this section we calculate the entropy value, MSE, PSNR and RIQMC values of ROHIM, NMHE and proposed techniques. we proposed an improved solution to predict the quality of image in this chapter. This chapter contains detail about algorithms and entropies using in proposed solution.This chapter also include experiments and results.

- Chapter 5: This chapter includes conclusion and future works.

Chapter 2

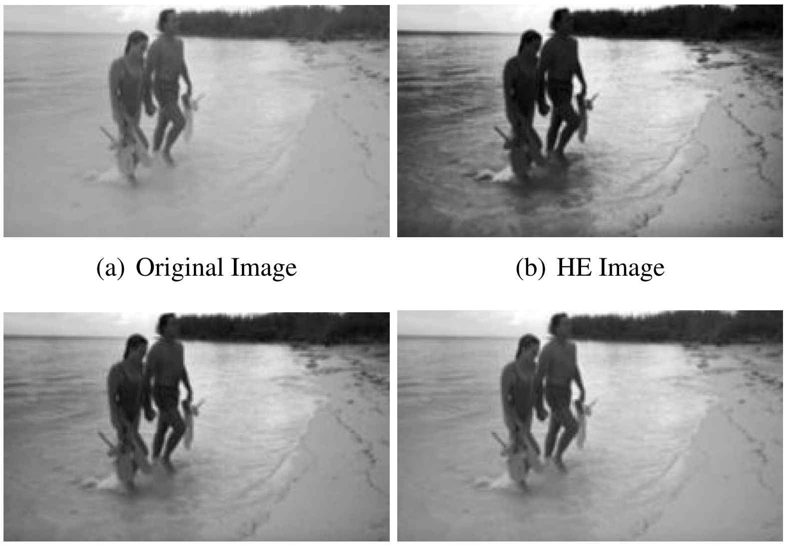
PRELIMINARIES

2.1 Literature Review

Histogram equalization is one of the better and simple way of enhancing the image by altering the input image histogram. Self-Adaptive Plateau histogram equalization (SAPHE) proposed by Kim [20]. Infrared images in which by suppressing the background main objects are enhanced, for filtration of input image histogram median filter is used and eliminate empty bins, produce better results for infrared images and has limitation other than infrared images. To solve this problem which occur in Kim and Chen [10] proposed Gray level grouping (GLG). Histogram components in efficient way are spread over the gray scale. Bins or gaps which were produced in [20] cause the under contrast or over contrast. Chen separate bins and uniformly distribute histogram over the gray scale and good for gray level images. Limitation or few drawback which occur in [10] are degraded sharpness in the images.

Histogram is divided and separate Sim [11] introduced recursive sub image histogram equalization (RSIHE). Probability density is chosen to 0.5 instead of mean to separate the histogram. Dualistic sub image histogram equalization (DSIHE) [15] median value is used to divide the histogram and in Recursive Mean Separate HE method (RMSHE) [16] mean value of the histogram is used. RSIHE is used to get more brightness and it overcome the problems occur in [15]. Sometimes it stretch the white/black contrast level due to domination of higher histogram components. which result in over brightness in that particular image.

Abdullah [12] proposed histogram based image enhancement technique which is dynamic histogram equalization (DHE) to avoid the domination of higher histogram components. Histogram of the input image is converted into sub histograms, this division takes place on the basis of local minima of histogram, furthermore these histograms are re allocated. Mean of the images preserve the brightness, where local



(a) Original Image (b) HE Image

(c) WTHE Image [15] (d) HMF Image [47]

Figure 2.1: Enhancement of images using WTHE [15], HMF [47] techniques

minima is used to control the stretching of gray level and has much application in that type of images which get over brightness but does not preserve the mean energy.

Ibrahim and Kong proposed an algorithm which is improved version of DHE [12] which is brightness preserving dynamic histogram equalization (BPDHE) [13]. Image smoothing is done in this algorithm by partitioning and equalization of input image histogram and this technique is based on local maximum value and have application for the images which has low contrast, but this method lost the natural appearance of the images. Menotti introduced minimum within class variance multi histogram equalization (MMCVMHE) [14]. Brightness of input and output image is almost same. Input image histogram is partitioned into sub histogram by minimizing with in class variance. It is more robust as compared to previous techniques and good to produces the natural look of the images and to get better PSNR value but this MMCVMHE is more complicated since optimal number of sub histograms are estimated from all possible sub histogram.

Wang [15] proposed weighted threshold histogram equalization (WTHE). Over enhancement and level of saturation are avoided. Original pdf is replaced by weighted threshold pdf. Images where upper and lower threshold (Degree of threshold) of image is not controlled by power law index. To enhance the contrast and preserve the brightness of image Kim and Chung [16] proposed Recursively separated and weighted histogram equalization (RSWHE) method based on mean or median of the images and power law function histogram is separated into two or more histogram resulted in histogram are weighted, excellent for preserving brightness but it is time consuming.

Spatially controlled histogram equalization (SCHE) method [17] is proposed by Abdullah. Newly obtained sub histograms are obtained until there is no dominating portion is present. Based on the input image dynamic range and CDF of histogram. There is disadvantage in this technique that little distortion is there in output images. Kim and Paik [18] proposed gain controllable clipped histogram equalization (GS-CHE) method. Mean brightness is used to detect clipping rate to calculate the maximum clipping histogram. Clipped histogram is corrected by local and global gain. This method is good for the preserving brightness but it is time consuming method.

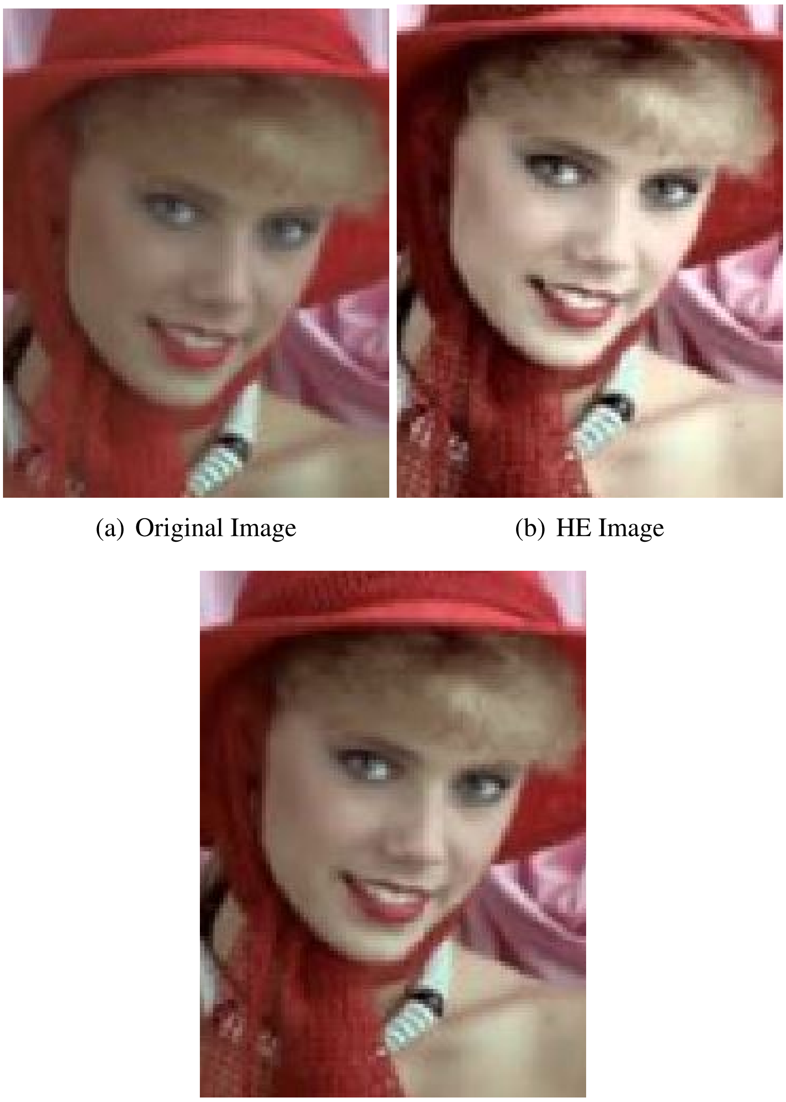
Park G introduced dynamic range separate histogram equalization (DRSHE) [19]. In this algorithm input histogram is separated into four equal sub histograms. Weighted average of absolute color difference (WAAD) is used to uniformly distribute intensities of the histogram. This technique preserves brightness but not preserve overall details of the Image. Natural appearance of the image is lost. Wang [20]work on flatness of histogram named as flattest histogram specification with accurate brightness preservation (FHSABP), flattest histogram is obtained with mean brightness then exact histogram specification is used to preserve the brightness. Maintaining image luminance is one of its advantages and its drawback is that generated image has side effects.

Brightness preserving weight clustering histogram equalization (BPWCHE) [21] method is proposed by Sengee. For given input image, non-zero values of bins are allocated. Clusters are created depending on weight ratio of cluster, width and the cluster weight. BPWCHE preserves the overall brightness and enhancing the contrast but its algorithm is computationally complex as we increase the number of images. Feng also worked on enhancement techniques named as Enhancement Algorithm for infrared image based on double Plateaus Histogram [22] method. Authors analyzed different features on infrared images. Upper limit is assigned as higher threshold value, and lower limit is assigned as lower threshold value. Advantage of this algorithm is that it can also enhance the dim small targets. Its drawback is that it sometimes enhances the background and noise.

The drawback which was in Ya-feng [22] paper that it enhance the background and noise is resolved by Ooi by using bi histogram equalization plateau Limit (BHEPL) [23] method. It is the combination of BBHE and clipped HE. Input image is separated into two sub images by using the mean brightness of image, then by applying the plateau limits the mean of intensity occurrence, these histogram are separately clipped and equalized. Main advantage of this technique is that it limits the enhancement so that it can enhance the dim light targets without enhancing the background and noise. Hence excessive enhancement and noise amplification which were in [22]are avoided by using BHEPL. Lin introduced histogram equalization technique which is based on mean and standard deviation of input image histogram, this algorithm is named as Statistic Separate Tri Histogram Equalization (SSTHE) [24] method. Histograms are stretched and equalized on each sub histograms.

Global contrast enhancement using histogram modification (GCE-HM) method is proposed by Arici. Level of contrast enhancement is decided based on special penalty terms. It is low computational complexity histogram modification, it stretch black or white gray level. Overall brightness of the input image is preserved. Sub region histogram equalization (SHE) [26]method is proposed by Ibrahim H and Kong. Convolution is used in this approach smoothed intensity values are obtained by convolving the input image with Gaussian filter. HE is used to get the transformation function which depends on both intensity of neighboring pixel and pixel itself and enhances the contrast and sharpens the image.

Adaptively Increasing Value of Histogram Equalization (AIVHE) [27] method is used for automatic contrast enhancement by adaptive contrast parameter which is depending on user defined parameter for bright and dark regions but it produces some artifact. Bi histogram equalization with neighborhood metrics (BHENM) [28] method described neighborhood metrics are used to create sub bins, histograms based on mean histogram pixel of equal intensity. Main advantage is that it removes bins and then equalized independently.



(a) Original Image (b) HE Image

(c) OCTM Image [5]

Figure 2.2: Enhancement of images using OCTM [5] techniques

Brightness preserving dynamic fuzzy histogram equalization (BPDFHE) is the fuzzy histogram method in which histogram is partitioned into sub histogram on the bases of local maxima. In this method author Sheet [29] proposed dynamic equalization for the partitions, the peaks of histogram are not mapped or equalized to preserve the brightness but it increase the contrast according to requirements. Dynamic quadrants histogram equalization plateau limit (DQHEPL) proposed by Ooi [31] which was based on the median of histogram. Histogram is subdivided into four sub histograms based on its median, limit is calculated and this is used to clip each histogram and then HE is applied independently. Mean brightness of input image is maintained by this approach.

Problem of over enhancement which was in [31] solved by Wu [32] by algorithm based on weighting mean separated sub histogram equalization (WMSHE) for contrast enhancement. Histogram is separated into six sub histograms based on weighting mean function. HE is applied on these sub histograms, over enhancement is avoided. Sub histograms are limited which makes the range limited. Thomas proposed piecewise maximum entropy (PME) method [33] based on piecewise linear transformation which is used to obtain accurate mean and results maximum entropy. It preserves the brightness of input image.

Zuo proposed range limited bi histogram equalization (RLBHE) method [34] is used for histogram thresholding. By obtaining two independent sub histograms thresholding object and background are separated. Minimum intra class variance which is the optimal threshold is calculated. Brightness is almost same as mean input brightness. Weighted average multi segment histogram equalization (WAMSHE) method is proposed by Khan [35] based on optimal threshold, input histogram is separated to multiple segments, equalization is performed on each segment, preserving brightness and enhancement in contrast compared to other multi histogram equalization. WAMSHE method has little limitation that it does not reduce the noise present in the image.

Adaptive contrast enhancement based on double plateaus histogram equalization (DPHE) technique [36] method is used for infrared images for low contrast and high bright background images based on local maximum histogram and minimum grey intervals, two parameters are calculated lower threshold value and upper threshold values. Upper threshold value is used to control over enhancement and lower threshold value is used to preserve the detail of the image. So the main advantage is that it preserves both contrast and brightness but on the other hand it has limitation of background noise.

Chulwoo proposed logarithmic based histogram modification HM method to avoid artifacts caused by HE. Power constrained contrast enhancement (PCCE) [37] developed a power consumption model which also controls the contrast histogram enhancement. Applications are in both still images and video sequences, but it has some limitation about power consumption. Jadiya worked on Optimal threshold for contrast enhancement and brightness preservation [38] method is implemented to preserve the brightness by increasing the difference between object and background. For this purpose Gaussian Parameters are calculated by genetic algorithm which decides the threshold to separate the input histogram. Gray level images are its main applications to enhance the images details.

Bi histogram equalization with adaptive sigmoid functions method is proposed by Arriaga [39]. Over enhancement and mean brightness shifting is avoided by separating input image histogram into two sub histograms using its mean as threshold. Median of sub histograms replaces the cumulative density functions. It has limitation of computational complexity because it uses continuous nonlinear mathematical function. HE based on the partitioned dynamic range approach is proposed by Shen Chuan. Algorithm [40] is the combination of probability density function (PDF) and range distribution function (RDF). Features of original image are maintain by PDF and loss of details or over enhancement is maintain by RDF. Usage of both PDF and RDF this technique also become complex and time consuming.
Honglie introduced the concept of double threshold range limited multi histogram equalization [41] method in which three divisions with the double threshold is used to separate the histogram. The important factor on which Honglie worked was to preserve the brightness, for this purpose minimum absolute mean brightness error (AMBE) between output and input image is maintained. This difference is maintained by calculating range of equalized image which is very useful in brightness preserving but it has limitation that new range of images are equalized separately. Enhancement dynamic quadrant histogram equalization plateau limit for image contrast method was proposed by Khalid [42] in which he divided input image histogram into 8 sub histograms. Median values are used for these sub division. Clipping of histogram also done in this method for individual histogram, and it is done by the average pixels. HE is done separately by assigning the new dynamic range and has many applications to preserves the mean brightness. Due to clipping method which is used in this algorithm there is chance that few information may be lost while applying dynamic range to each sub

histograms.

2.2 Histogram Equalization Methods

2.2.1 Classical Histogram Equalization.

Classical histogram equalization (CHE) method describes for monochromatic images in details. CHE method is the core of other HE methods. In image contrast enhancement technique there is very wide use of histogram equalization in different applications. Histogram equalization (HE) working can be broadly divided into two main steps by flattening the histogram and the other step is enlarging the gray level range. Concept of flat histogram is used in this technique, CHE tries to produce an image which has flat histogram. The image which has flat histograms means that particular image has the maximum information with respect to its original image for example entropy. Significant change in image brightness that is gray level can introduce in this method. CHE method shifts output image brightness to the median gray level due to uniform distribution of the output histogram. CHE technique based on CDF and good enhancement technique, it has drawback of degraded sharpness, creates artifacts and does not preserve brightness.

2.2.2 Brightness Bi Histogram Equalization.

Brightness bi histogram equalization methods (BBHE) overcome the drawback which was introduced by CHE. It preserves the brightness of image. Histogram Equalization is made on two sub images without producing any artifact it maintains the value of brightness of an image. It maintains it from the center of image and preserve the brightness and equalized the histogram, this is also called hybrid method. BBHE also have disadvantage of higher degree of brightness preservation which is not possible to avoid annoying artifacts.

2.2.3 Dualistic Sub Image Histogram Equalization.

It distinguishes the histogram with function cumulative probability density (CPD) having the value 0.5. Whereas in BBHE centre of gray level images was taken to obtained mean. In the both methods BBHE and DSIHE images are decompose. The aim of decomposition of images is to increase the value of Shannons entropy of images which are obtained at output or at receiver end. We achieve the output of DSIHE in a single image by combining the sub images. The DSIHE method decomposes the images aiming at the maximization of the Shanons entropy of the output image. The simulation results of this technique indicates that algorithm enhance image information effectively as well as it keeps the original image luminance well enough. Advantage of this technique is that image luminance is well maintained and its drawback is natural appearance of the image is lost.

2.2.4 Recursive Mean Separate Histogram Equalization

In RMSHE technique the factor r is an important aspect. The previous techniques decomposes the images only once but in (RMSHE) method images decomposes many times until it reaches the scale r, where r= 0,1, and produces 2r images. So in RMSHE technique we obtains 2r sub images after this to enhance each sub images Histogram Equalization (HE) method is used. Here two histograms are plotted, when we put value of r equal to 0 and when r=1, When r has zero value: No sub images are created.When it has value 1: Sub images are generated In both the cases when r=0, and when r=1 histogram before and after HE are equivalent to the RMSHE method. Mathematically, it is analyzed images of average output brightness coverage the average number of recursive mean separation increases. Advantages of this technique is that it enhances all regions of image, where its drawback is that number of decomposed sub histograms increases in a power of two.

2.2.5 Minimum Mean Brightness Error Bi-Histogram Equalization

Histogram is partitioned based on the threshold level which is equivalent to minimize the difference between input mean and output mean. The advantage of MMBEHE is provides maximum brightness reservation, and its drawback is that it generated image has side effects performance degraded.

2.2.6 Multi Histogram Equalization

In this technique image is decompose into sub images. HE in each sub image contrast enhancement is less intense which makes the output image more natural look. Image enhancement is done in two steps first divide the histogram into classes secondly determined the threshold levels, where each histogram class represents a sub image.

2.3 Histogram Modification

In Histogram Modification Framework (HMF) techniques Arici and Salih [47] explain the modification of histogram which is less complex and compacts with spikes of histogram, perform white and black (W and B) extending handling the noise visibility and the energetic range this algorithm adjust the level of enhancement adaptively. Main two steps of Histogram modification framework algorithm are histogram Computation and adjusting the level of enhancement. In [47] histogram spikes was computed by flattening the given histogram, which was one of the complex method. HMF technique deal spikes of histogram by a good way. Huge amount of pixels which have almost equal gray level comes from a given image, so spikes are created because these gray level pixels create noise and objects in the image which is enhanced. Histogram spikes problem can be solved at very beginning by modifying the histogram computation including that pixels which have little amount of contrast.

$$h = \frac{h_i + \lambda_u}{1+\lambda} = \frac{1}{1+\lambda} h_i + \frac{\lambda}{1+\lambda} u \tag{2.1}$$

Purpose of h Modified Histogram, λ problem parameter, h_i input histogram and u uniform histogram is to adjust the level of enhancement is to attain actual looking of those images which are enhanced. Pixels which are the part of histogram are obtained to make sure the bin regions which are very low in the low slope is not as a result of mapping function, so in these regions it will increases the slope, purpose is to increase deployment of vigorous range.

The histogram modification framework algorithm is compared with contrast enhancement algorithm which is recently proposed. HMF algorithm compared its subjective assessment results with Histogram Equalization (HE) and Weighted Threshold Histogram Equalization (WTHE). Both WTHE algorithm and the algorithm which is proposed in this paper show similar visual quality on many tested images. However some images are selected which shows better visual quality in proposed algorithm. In HE algorithm, for maximum contrast histogram equalized images result in the good utilization. However, this does not mean that images which are looking good or those images which are which are better in term of visual quality are considered to be good images. With different types of images this condition is preceived which are shown in above figure. The artifacts which are undesired become projecting, and also increase the amount of noise which results in degrades the image quality.

Slope in the mapping function become higher due to spikes of histogram. HE and WTHE algorithm results are not better and that results are also not updated. Due to the artifacts images is shrunk from either one side or both sides which results as either make the image unnecessary more brightened or some time more darkened. Contrast enhancement can easily be stretched in color images. Chrominance components are used to stretched the gray-scale to color images by contrast change, this is the most obvious way to luminance components. To attain the Hue there are different ways, one can multiply chrominance value with the input output luminance ratio. HMF algorithm computed the measurment of quantitative results of brighteness error which are absolute mean, Entropy in the discrete form denotes by H and EME denotes the Enhancement measurment. In HE, there is small value of S shaped mapping function, thats why HE gives very little value of AMBE. In bright images the mapping function which is S shapped makes its pixel more brighter, similarly in darkened images this mapping function makes its pixels more darker. The same reasoning applies to the Weighted Threshold Histogram Equalization (WTHE).

Optimal Contrast Tone Mapping (OCTM) [5] Xiaolin formulate the problem of OCTM, its main purpose is to attain subtle tone and better contrast which are reproduce at the same time. In OCTM formulation it identify the function for the images of uniform histogram, that function is taken as a transfer function.

Although images having the uniform histogram cannot be enhanced further, so here Histogram Equalization (HE) algorithm fails to enhanced the Image, so here OCTM formulation optimize the transfer function for a balance contrast and best subtle tone to user preference and application requirements. OCTM algorithm is organized as follow [5] in this algorithm remapping of input and output of images used to attain the contrast enhancement by increasing the difference between two adjacent gray level.

When we are going to reproduce a L gray image which is digital level such type of mapping is necessary. The transfer function which is used here is integer to integer. Physical and the psychovisual common sense is also an important aspect, so in order to maintain this aspect the as the function T has no ability to reserve the intensities values, so this function should be non decreasing.
In Contrast Tone Optimization by Linear Programming the contrast enhancement two most important factors are resource and constraints. The output range which is utilize here is resource and the tone restoration is the constraints. The output devices along with its dynamic ranges are the important factors for the confinement of the tone distortion D(s), The contrast gain G(s) is also a factor for the confinement purpose. L input level images are very higher skewed which are allocated at L output levels, than some necessary representations of some input images can deny and sustaining distortion which is related to its tone. Due to this there occurs some problems in an image like unnatural behaviour of bands and the shades which are totally flattened etc. Other researchers noticed these type of artifacts as a drawback of original histogram, and large amount of ad hoc is suggested by them.

In OCTM these problems realized, and these side effects of contrast enhancement control in OCTM algorithm when we maximize the constraints value which is the gain of contrast G(s). The OCTM technique fulfill the desired visual effects, it can achieve by including additional constraints in the previous last equation. Thee generality and the flexibility of the OCTM algorithm can be demonstrate by some of the many possible applications.

Integration of Gamma correction is the first example for the contrast tone optimization. We can made very close optimized transfer function T(s) to the gamma function by accumulation of different constraints value. The contrast tone mapping is globally focused in this OCTM algorithm. For the different types of images we applied OCTM technique separately obtain the statistics of a local image. The regions in the adaptive histogram equalization are processed independently to each other. So to prevent block effects linear weighting scheme is used. The purpose of liner weighting scheme is to fuse the results of neighboring blocks and hence it prevent the block effects.

Adaptive Gamma Correction With Weighting Distribution works on the images which are dimmed in nature or somehow they become dimmed can be enhanced by direct and indirect enhancement. The specific contrast term is defined the contrast of an image in direct enhancement method. Conversely indirect enhancement method contrast of images is enhanced by using probability density function. In other words we can say in indirect enhancement method intensities of the images are redistributed over the dynamic range.

AGCWD fusion HM method *Huang et al.* [1] is used to accommodate balance. As discussed in RSWHE method that modifies each sub histogram with brightness preservation by using normalized gamma function. However, some data or information might lose in these modified sub histogram. So to prevent this and without losing any statistical information. Transformation curve is modified by using gamma function and pdf and compute the entropy by.

$$H(y) = -\sum_{0<i<max} P_i(y).logP_i(y) \tag{2.2}$$

Where $P_i(y)$ = Probability density function of ith gray-scale of Image y and $log(.)$ = Here we use the log of base two. In some methods normally when we enhanced the images there is significant decrement of high intensity images, but intensity of an image is sustain in a better way because it avoid the decrements in intensity value.. There are some adverse effects occurs in an image, so to lessen these adverse effect and to modify the statistical histogram Weighting Distribution (WD) function is applied.

The images which are dimmed uses as a input image, and these images densely distributed in the low level region. In this it is first time happened the cumulative effect of weighting parameter, cdf and gamma function are used which enhance a color image without decrements of the high intensity images, not even generating the artifacts or distorting the colors.

AGCWD technique is further extend by using a technique which is temporal based (TB) which is less complex of the AGCWD model used for the video contrast enhancement.

Difference in the information contents are measured by using entropy model between two successive frames. Image enhancement method based on Fuzzy-Logic and histogram is based on histogram algorithm [2] is computationally fast method as compared to as compared to conventional and other advanced enhancement algorithms. This algorithm depends on the two parameters are $M\ Parameter$ and $K\ Parameter$ $Mparameter$ denotes the intensity values which are average. This average intensity value is calculated by the histogram. Contrast intensification of an image is denoted by the $parameterK$. To sustain the information about original image which are chromatic the Red-Green-Blue RGB image is transformed into HSV color space. In the HSV the component V is used for controlling the parameters M and K.

In Fuzzy Logic enhancement method the parameter V in the HSV image is used to preserved the information which are chromatic that are Hue (H) value and the value of Saturation (S). Initially the proposed method is to convert RGB image in the HSV image. Histogram h(x) is calculated after conversion into HSV, this histogram indicates pixel values, and x denotes the intensity value of an image. As it is discussed before that there are two parameters are used M and K, these parameters are used to control the degree of intensity value x, that how much x has to be intensified.

The $parameterM$ has very important role to calculate the fuzzy membership values. Larger the value between X and M, smaller will be the intensity of stretching. The above rule indicates that the pixel values which are closer to the parameter M will be extended higher, and those values which are away from the parameter M that are lesser extended.

2.4 Analysis Of Image Contrast From Quality Assessment To Automatic Enhancement

Contrast change can improve the quality of most of the images. In this paper RIQMC is used to change the contrast of an image [43]. RIQMC calculate the PC based values and compute statistical knowledge of the histogram of that image. After combining the subjective and objective assessment this paper derive the RIQMC based Optimal Histogram Mapping (ROHIM) for contrast enhancement automatically. Spatial domain methods which directly operates on pixels. It is based on the pixels of the images which are in direct manipulation and the image plane itself. The spatial domain is a very simple and easy to understand, less complex and favors the real time implementation. Two subcategories of spatial domains are Point Processing operation and Spatial Filter operation. Point Processing operation this occurs when the neighborhood is simply the pixel itself, it is used for contrast enhancement. In spatial filter operation spatial filtering is repeating for every pixel in the original image to generate the smoothed image. Three main factors for the spatial filtering are area shape and size. Area size is determined through mask size and the mask is an important parameter. Area shape is defined using a rectangular mask.

Frequency domain is operating on the Fourier transform of an image. In this method on the pixels of an image spatial domain has direct impact. These operations are divided in two main categories are Single pixel operations and Neighborhood Operations. Single pixel operation is a very easy operation which is performed on an image to change pixels values which are depend on intensity value of that image.

Neighborhood Operations generates the output pixels by combining the small area are neighborhood pixels. Convolution is the most important neighborhood operator. In digital imagery convolution refers that a local area pixel is combined in different ways to get some desired outputs. There are many applications of neighborhood operator for example wrapping images, digital filters to techniques for sharpening, transforming images. Spatial Geometric transformation modifies the spatial link between pixels of images. Basic operations of Geometric spatial transformation are ”A spatial transformation of coordinates” and ”Intensity interpolation”.

There three main Image quality assessment methods are Full Reference Method, Reduced Reference Method and No-Reference Method

2.4.1 Full Reference Method

Two well-known objects models Peak Signal To Noise Ratio $PSNR$ and Structural Similarity Index Model $SSIM$, it assume that the image which is distorted is entirely known, afterward to pursue the better performance designed the improved $SSIM$ type ofIQA methods.

For the view point of the information Visual Information Fidelity VIF is defined, and for detection and appearance based scheme Most Apparent Distortion MAD is defined.

2.4.2 Reduced Reference Method

When the pristine image is partly available for IQA task than we use the Reduced Reference RR method. The size of the RR information is limited to lesser in size as compared to the size of the original image. So in this technique Free Energy Based Distortion Metric $FEDM$ is intended. This is designed to detect the internal stimuli of human brain model. Two different type of quality measures Fourier transform based quality measure $FTQM$ and the other one is RR entropic difference indexes $RRED$ were established in discrete domain and wavelet transform domains independently.

2.4.3 No-Reference Method

When the original image signal is not available than to handle these types of problems we undergo growing number of No-Reference (NR) method. Support Vector Machine. So no reference image quality assessment is used to predict the visual quality of distorted images without examining the original image as a reference. Already proposed no reference image quality matrices are designed for one or set of predefined distortion types degraded with other types of distortion for evaluating images. There is strong need of no reference image quality assessment methods which are applicable to different distortions. A generalized Gaussian model is used in previous algorithm to summarize the marginal distribution of different images. The dependencies estimate the corresponding value in the reference image. No reference method is easy to implement and efficient in computation.

Experiments on different images from database demonstrate the efficiency for several properties of the method may be of interest for real world users. No reference method is general purpose method that perform well for a wide range of distortion and need no information of reference image. The method is easy to implement and need less parameters. In no reference method measurment is based on marginal distribution so the method is insensitive to small geometric distortions such as spatial translation, rotation and scaling.

2.5 Qualitative Attributes Of An Image

Some of the qualitative attributes of an image are peak signal-to-noise ratio, mean square error, root mean square error, least-mean-square error and normalized cross correlation.

2.5.1 PSNR Peak signal-to-noise ratio

It is simply the ratio between power to noise corrupting of a signal, here power should be maximum possible. Noise that corrupt the original signal affects its representation are original signal quality reconstruction the noise refereed as error, whereas the signal is the original data.

2.5.2 MSE (Mean Square Error)

The difference between PSNR and MSE is that PSNR which is peak error where MSE is error which is commulative and squared. This error is in original image and the compressed image.The relationship between MSE and PSNR can be seen by the following formula.

$$PSNR = 20log_{10}(\frac{255}{MSE^{\frac{1}{2}}}) \tag{2.3}$$

From the above relation we conclude the following results. Lesser the MSE value, error will be lesser, inverse relation between PSNR and MSE, this translates that high value of PSNR leads to lesser the MSE. PSNR have better value indicates better image. For better results MSE should be low and having higher PSNR.

2.5.3 RMSE Root Mean Square error

RMSE is used to calculate the measure of similarities of two images. Similarly to find the difference between two images we can also use the Root Mean Square values.

2.5.4 LMSE (Least-Mean-Square error)

To calculate the difference and variation between desired signal and the original signal we produce the least mean square error signal. LMSE conclude as calculate the change in prediction and model value of the signal, we calculate this difference at the several different places. Square the error to make value positive. Calculating the average of the signal (Mean Square), find that model which gives us the very less error.

2.5.5 Normalized Cross Correlation

It can be written as

$$CrossCorr(s,t) = \sum_{x}\sum_{y} R(x,y)I(x-s,y-t) \tag{2.4}$$

I = intensity of Input image and R = intensity of Reference image. Summation is the common area between Reference and Intensity image. Maximum value of $CrossCorr$ $=I(x,y)$ best matches$R(x,y)$ Image can be judged either it is bad image or good image, it is based upon the above parameters. For very good image, ranges of correlation is from 0 to 1 (from good image to bad image).

2.5.6 Phase Congruence (PC)

Phase Congruence is the matrix which measure the quality. We can improve previous technique by using the important parameters Phase Congruence (PC). The similarity measure for the phase congruence PC is given by

$$PC = \frac{2PC_1(x,y)PC_2(x,y)}{PC_1^2(x,y) + PC_2^2(a,b)} \tag{2.5}$$

two PC maps that are separately computed by applying PC to the pristine image and its contrast-changed version are almost the same, since it is invariant to changes in image brightness or contrast. PC maps computed from different images of the same image content.

Chapter 3

Proposed Method

For Image quality assessment techniques there are three most well-known objective models are used. First one is Full Reference model, which assume that the image which is distorted and the original image is known. Second is Reduced Reference which works under the circumstances where the some part of the image is known (partially available) to assess the IQA. Third is No Reference in this signal is totally unavailable, SVM is also category of no reference method which calculate the relationship between chosen features and the human rating.

In the proposed technique we take different test images and apply reduced reference image quality matric for contrast change. Reduced reference , non reference and full reference all these three model does not produced the satisfactory results, then we can improve the results of the images by using Gamma transfer function, Convex and concave arc and Cubic and logistic function.

$Gamma\ Correction\ function$

Gamma correction function to individual pixel values is a non-linear adjustment. We carried out linear operations on individual pixels in image normalization, such as scalar multiplication and addition, subtraction; gamma correction carries out a non-linear operation on the image source pixels, and can cause the image being altered. Furthermore it can also lead to poor contrast if the gamma value is too large or too small.

Gamma correction appears to either darken or brighten an image. We already adjust the average brightness of an image by some modified normalization algorithm, the simplest of shifting which would be simply adding the contrast value to each intensity pixel value. Exponential function can effectively carries out on individual pixel values by gamma correction.

For mathematical analysis, the gray scale intensity value of an output image is defined as y, and the input intensity value is defined as x. and the gamma value is defined as

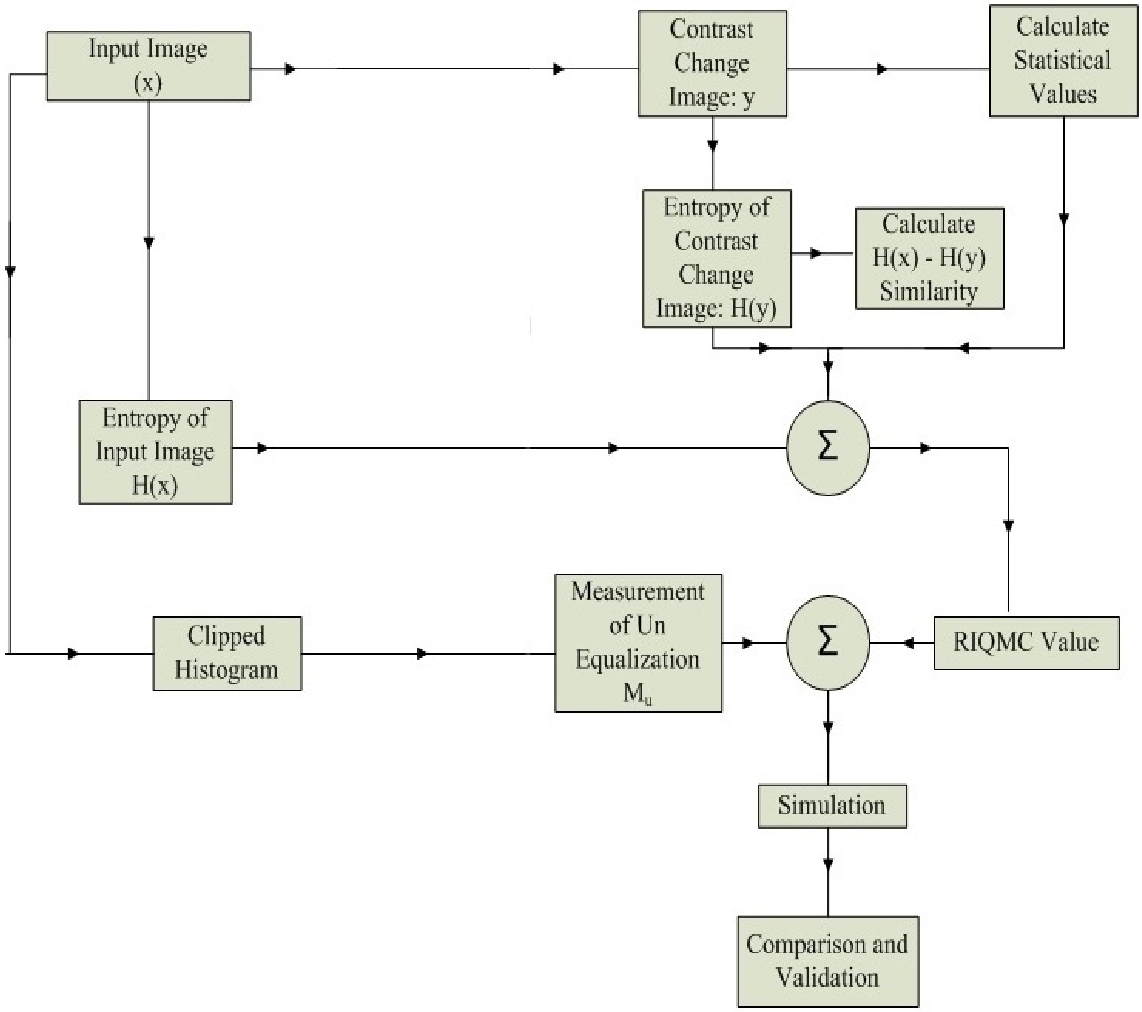


Figure 3.1: Proposed Model

γ. The relationship between input and output image can be can be described by the equation below.

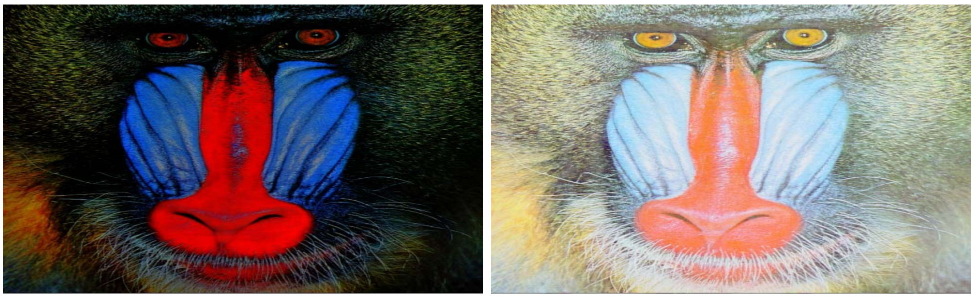
$$y = x^{\gamma} \tag{3.1}$$

Consider we are using gamma distortion corresponding to gamma value, it specifies the pixel value to appear on screen. If we carry out the inverse of the above mentioned equation , prior to display the pixel on screen, then we have to compensate for the gamma adjustment due to display.

The real trick with gamma correction is determining the gamma value by either design algorithm or can simply guess and test values mathematically to compute ideal gamma

(a) Lena Image with gamma 0.25 (b) Lena Image with gamma 2

Figure 3.2: Lena Image



(a) Mandrill Image with gamma 0.25 (b) Mandrill Image with gamma 2

Figure 3.3: Mandrill Image

values.

Here we have the Lina and Mandrill images had the gamma corrected using a gamma of 0.25 and 2.00: The range of values used for gamma will depend on the application, normally we use a range of 0.01 to 7.99.

Logistic Function

Many data sets may be effectively fitted with concern mathematical model, so here a mathematical model which we choose for effectively fitting the data sets is the logistic function. The logistic function which we use in our thesis work is three order cubic functions and four parameter logistic functions. The logistic function is given by the formula

$$y = \frac{b_1 b_2}{1 + \exp^{-\frac{x-b_3}{b_4}}} + b_2 \tag{3.2}$$

Parameters $a_1 a_2 a_3 a_4$ and $b_1 b_2 b_3 b_4$ are determined by optimal transfer curve. This optimized process is performed by MATLAB function nlinfit. The optimal transfer curve can solely be determined for our four parameter logistic function. *Compound*

Function

Further compound function is used with mean function followed by the logistic function. Mean shifting function is the procedure where maxima is located of given discrete data sampled function. This function is used for the estimation of mean to determine the weight of nearby points. So compound function is used with this mean shifting function followed by logistic transfer function. For valid enhancement properly combining mean shifting and logistic function to obtained compound function.

After all transfer functions processed above the produced images were clipped into the range of 0 to 255 out of bound values.

3.0.1 ROHIM Model

Researchers mainly focus on to measure the difference between the original image and distorted image for this they focus on noise, blur, transmission error etc to predict the quality score. In general ideal version of image has greater perceptual quality as compare to corresponding distorted image. WE basically focus on the main artifact of image which is contrast change which is distinct from the above distortion type. The reason is that the image processed by the proper histogram mapping can obviously improve image contrast and visual quality.

RIQMC is used to examine difference or similarity in original image and distorted image to calculate the quality score of that image. This model is basically three stages framework includes Similarity, Comfort and Fusion Similarity the first step we make the comparison of similarity between two images the original and contrast image taking in view that image which is higher in quality should not away from its main copy. Normally humans focus on two types of features of an image the silent features and the important region. So to search for the important features Phase congruency PC based value are calculated before entropy difference approximation between original image and contrast change image. Facts and figure for a random signal is represented by the very important concept of statistics i.e. Entropy.

In this section Entropy for the contrast change image is represented by H(y), and entropy of original image is represented by H (x).

Entropy for the contrast change Image H(y)

$$H(y) = -\sum_{0<i<255} P_i(y).logP_i(y) \tag{3.3}$$

Where:-

$P_i(y)$ = Probability density function of ith grayscale of Image y.

$log(.)$ = Here we use the log of base two

Phase congruency (PC) model has been used to identify the different features in a signal. To measure the PC as we know that the entropy measures the unpredictability of the image signal, therefore we work out on similarity and entropy change of the original image and contrast change image.

Similarity is denoted byR_0

$$R_0 = H_s(y) - H_s(x) \tag{3.4}$$

$H_s(x)$ = Entropy of original image

$H_s(y)$ = Entropy of contrast change image

Here we noticed that the PC values which obtained from the original image and from contrast change image is almost the same. It means PC based value collecting from different images the factor similarity is greatly similar. In Comfort framework of RIQMC we measure the comfort level of the image by computing the four factors which are Mean (First order statistic), Variance (Second order statistic), Skewness and Kurtosis.

$Mean$

Here we use the weighted mean of the contrast change image y, which determines the overall brightness of the image. Cameras usually have a function that is called gamma function, by adjusting this function cameras can adjust the brightness of the picture, but some time improper selection of gamma functions will affect the visualization and deteriorate the Image contrast. So to get rid of all these problems we compute the comfort of image by calculating weighted mean first.

In simple mean each data point contribute equally, but in weighted mean each data point does not contribute equally, the data point contribute larger or more weight than other. Simple mean and weighted mean acting as same if all the weights of data points are same. Formula for the weighted mean is given by

$$R_1 = \frac{\sum_{1<i<n} x_i.w_i}{\sum_{1<i<n} w_i} \tag{3.5}$$

x_i = Data point of the image

w_i = weight of that particular image

$Varience$

It is called the second order statistics.It is basically the function of contrast which is free from context . The aim of calculating variance is to make the difference between the images greater which change input gray levels.

We calculate the variance by

$$R_2 = E(y_h^2) - E(y_h)^2 \tag{3.6}$$

y_h = Histogram of image y $Skewness$

Skewness is used to measure the perceptual surface quality. It is basically calculate that how much the images are symmetric. Skewness is used to estimate the judgments of the contrast. When the image which is skewed positively, it means that Image will appears as more darker as compare to the image which is lesser skewed. Larger the skewed, larger will be darker and vice versa.

$Kurtosis$

The purpose of calculating kurtosis is to measure the quality of contrast changer images. Kurtosis which is more higher in order is used to measure how much flat an image is. We examine that the images which are largely skewed are sometimes look unnatural have more brightness. Kurtosis values of the images which are contrast change have larger value as compared to the original images.

In fusion section we associate together the similarity and the comfort to find the quality score of the images which are contrast change. So the combined effect of RIQMC can be written as

$$RIQMC = -r_0.H_s(x) + r_0.H_s(y) + \sum_{0<i<4} r_i.R_i \tag{3.7}$$

$H_s(x)$ = Entropy of original image.

$H_s(y)$ = Entropy of contrast change image.

r_0 = Optimized factor (contrast related subsets).

R_i = Comfort parameters.

PC based entropy of the original image Hs(x)is an important factor which RIQMC model requires. usually this parameter can be ignored because of very high size of image.

3.0.2 Automatic Contrast enhancement (ROHIM)

Proper compound function (i.e. mean shifting function followed by logistic transfer function) can generate better contrast and visual quality images. Then we proposed RIQMC model to demonstrate its superior performance and statistics information of the image. In this section contrast enhancement process is discussed, contrast enhancement process is a blind process, requires NR IQA metric with optimization function which is discussed in mathematical model section to find the optimal histogram mapping. RIQMC based optimal histogram mapping (ROHIM) based on two steps which are Mean shifting function and Logistic function Mean shifting function have input image x, now to alter the input image x, we use mean shifting function.

$$X = x + \triangle \tag{3.8}$$

Where $\triangle$ is computed by optimization operation.

Logistic function is computed by

$$y = F_l(x, b) = \frac{b_1 + b_2}{1 + e^(- \frac{x - b_2}{b_4}}) + b_2 \tag{3.9}$$

The above given logistic function has four parameters b1, b2, b3, b4 which are to be determined, by this optimal transfer curve can solely be determined.

3.0.3 NMHE.

Non parametric modified histogram equalization for contrast enhancement (NMHE) in this model we do not use any parameter for contrast enhancement. This technique is independent of the parameter. For better quality image this algorithm compute spatial transformation on gray scale by the use of modified histogram.Important parameters for spatial transformation are Clipped Histogram and Measure of Un-equalization (Mu) Clipped Histogram is the first step in which spikes are removed from the original histogram. We compute the modified histogram by removing spikes from histogram, for this we considering only those pixels which have dissimilarities with their neighbors. The computation of this modified is very simple and given by the following equation.

$$h_mod(i) = p[\frac{i}{c}] \tag{3.10}$$

where

$p[\frac{i}{c}]$ = It tells us about that how much probability of ith gray level to occur.

C = Contrast deviation in horizontal direction.

Clipped histogram computed from hi is given by

$$h_{modc}(k) = \frac{1}{L}, if h, k > \frac{1}{L} \tag{3.11}$$

$$h_{modc}(k) = h_i(k), if h, k < \frac{1}{L} \tag{3.12}$$

Measure of Un-equalization M_u) tells us about the histogram attributes that the image histogram does not track a distribution which is uniform. So redesigned of NMHE histogram and CDF of Image can be calculated as

$$h_{NMHE}) = (M_u)h_mod + (1 - M_u).u) \tag{3.13}$$

$$c_{NMHE} = \sum_{0<i<k} h_{NMHE}(k) \tag{3.14}$$

So the output image produced by NMHE

$$I_{NMHE} = INMHE(i, j) = T(I(i, j) \tag{3.15}$$

The intensity and brightness of an image can be preserve and improved by following factor.

$$y = log(\frac{mean(i)}{255}).log(\frac{mean(I_{NMHE})}{255}) \tag{3.16}$$

Proposed work have examined the problem of IQA for contrast change and application which are related to automatic image enhancement. Main contributions which we have made, firstly contrast change image database created by various kind of contrast oriented transfer functions like gamma correction function, logistic function, mean shifting and compound function. Automatic contrast enhancement ROHIM model present the subjective and objective assessment for image contrast.

In this algorithm Phase Congruency (PC) based values are obtained for database images. In RIQMC Algorithm two stages Similarity and Comfort are deeply described in this chapter. First quantify the similarity by calculating the entropy difference of output image and input image while comfort stage is consist of first order, second order, third order and fourth order statistics

Furthermore combine aforesaid subjective and objective assessment to derive the $RIQMC$ based Optimal Histogram Mapping $(ROHIM)$. This algorithm justifies effectiveness in comparison to recently designed models. $ROHIM$ also consist of two stages, automatic contrast enhancement and performance comparison which can enhance images better than recent enhancement technologies.

After $ROHIM$ algorithm for improving the contrast of an image which however leads to an over enhancement of the image. So to get rid this over enhancement and unnatural appearance in the image Non Parametric Histogram Equalization $(NMHE)$ algorithm is used. This methodology preserve the brightness of original image.

Experimental results show that proposed algorithm produces better or comparable enhanced images than several images.

Chapter 4

RESULT AND ANALYSIS

Assessments of images are analyses by quantitative measure. For the quantitative measure we consider the measurement which are Entropy, Peak Signal to Noise ratio, Mean Square Error and RIQMC Value. The result of our proposed work is compared with the existing techniques. By observing the enhanced images, it appears that the Peak signal to noise ratio (PSNR) value of the contrast change image by using proposed technique is much better as compared to previous techniques. Similarly Mean Square Error (MSE) value of the proposed is comparatively less than the other previous techniques.

Illustration of existing techniques and the proposed method appears that proposed method is the method on which image is produced with balanced contrast improvement; it also appears as a natural look. Other techniques produce artifacts. NMHE technique is limited for the contrast of those particular images. In the ROHIM technique image become brighter which also affect the quality of the image, whereas in proposed model image enhance the contrast at particular range preserving the colors of the images. In figure 4.1 (Party image) ROHIM Technique makes the image much brighter which seeks the trade off between the input image and ROHIM image. ROHIM improves the contrast of input image but it look much brighter. while the NMHE technique preserve the brightness of the original image as compare to ROHIM. NMHE provide proper brightness but it cannot totally overcome the noise injection. Propsed technique effectively avoid artifacts and preserve details.

In fig. 4.2 (Butterfly Imge) ROHIM technique enhanced the image in such a way that it lost the original color of butterfly as well as the background. NMHE well restrain the colors of the image but it did not enhanced the image and also not good for adjusting the luminance. Proposed technique completely remove the noise artifacts and preserve the intensity value of the image.

(a) Original (b) ROHIM [54]

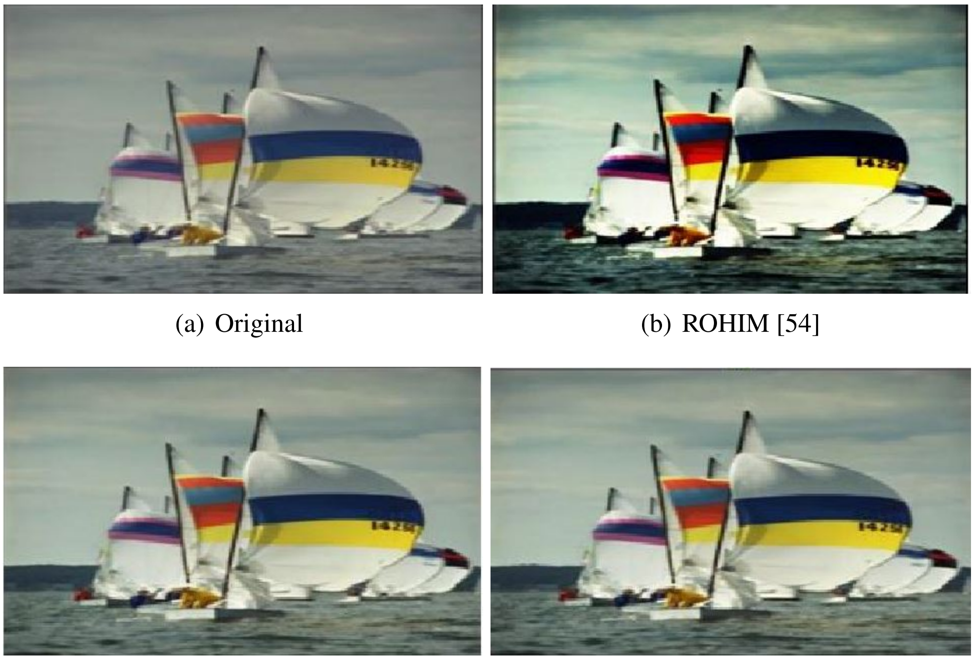
(c) NMHE [77] (d) Proposed

Figure 4.1: Party image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques

(a) Original (b) ROHIM [54]

(c) NMHE [77] (d) Proposed

Figure 4.2: Butterfly image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques



(a) Original (b) ROHIM [54]

(c) NMHE [77] (d) Proposed

Figure 4.3: Ship Image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques

In fig. 4.3 (Ship image) ROHIM technique makes the color of sea water as well as the sky color darker. It did not enhance the image properly. NMHE technique gives little bit better result than ROHIM but it increases the intensity value of image which make image brighter. Proposed technique makes enhanced image of more suitable luminance and glossier than state of the art ROHIM and NMHE techniques.

In fig. 4.4 (Girl1 Image) ROHIM technique does not give proper brightness and inject noise so that flowers and the face of the girl become much brighter. NMHE enhanced the input image in a better way, but it observes that enhanced image created by NMHE looks quite dull and pale. Proposed technique provide high accuracy enhanced image which well correlates with human perception.

In figure 4.5 (Girl2 Image), The output of ROHIM Technique is too dark in overall appearance. NMHE technique provides unacceptable distortion in average intensity. Proposed technique bounds the relative difference between the average intensities of the input and output image.

(a) Original

(b) ROHIM [54]

(c) NMHE [77]

(d) Proposed

Figure 4.4: Girl1 Image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques

(a) Original

(b) ROHIM [54]

(c) NMHE [77]

(d) Proposed

Figure 4.5: Girl2 image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques

(a) Original (b) ROHIM [54]

(c) NMHE [77] (d) Proposed

Figure 4.6: Hand shake image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques

In fig. 4.6 (Hand Shake Image), ROHIM Method obtains high contrast in this image. The output of NMHE obtains small noise and the background of this image become darker. Proposed technique increases the perceptual quality of the image.

In fig. 4.7 (Restaurant1 Image), Result of ROHIM increases the brightness so that the picture in the screen is not clear. NMHE increase the contrast and brightness, but it not preserves the general shape of the image. Proposed technique provides proper brightness and maintains the general shape of the image.

In fig. 4.8 (Restaurant2 image),Original image is much darker the output image obtain after applying ROHIM is acceptable image but it has unnatural or limited contrast. NMHE technique also enhanced the image but it contains serious artifacts in some portion of the image. Proposed method preserve the brightness and remove the noise and makes the image more clear.

(a) Original (b) ROHIM [54]

(c) NMHE [77] (d) Proposed

Figure 4.7: Restaurant1 Image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques

(a) Original (b) ROHIM [54]

(c) NMHE [77] (d) Proposed

Figure 4.8: Restaurant2 Image: Enhancement of images using ROHIM [54], NMHE [77] , Proposed techniques

Table 4.1: Entropy, MSE, PSNR and RIQMC values.

Image	Technique	Entropy	MSE	PSNR	RIQMC
Party	ROHIM [54]	2.06	45.96	5.58	-1.92
	NMHE [77]	4.01	43.93	6.50	3.69
	Proposed	80.37	29.11	6.6	4.16
Butterfly	ROHIM [54]	6.3	102	28	-6.2
	NMHE [77]	7.3	82	30	-0.19
	Proposed	7.4	40	32	0.09
Ship	ROHIM [54]	6.8	92	28	-1.4
	NMHE [77]	7.3	43	31	1.2
	Proposed	7.4	32	33	1.4
Girl1	ROHIM [54]	6.5	16	36	-2.8
	NMHE [77]	7.3	3.17	43	2.1
	Proposed	7.4	1.59	46	2.2
Girl2	ROHIM [54]	6.9	143	26	-3.03
	NMHE [77]	7.4	107	27	0.23
	Proposed	7.5	69	34	0.33
Hand Shake	ROHIM [54]	3.1	102.94	28.03	1.5
	NMHE [77]	6.5	6.67	39	3.5
	Proposed	6.6	6.34	40	3.7
Restaurent1	ROHIM [54]	5.8	177	25	-0.9
	NMHE [77]	6.5	14	36	3.4
	Proposed	6.6	11	37	3.4
Restaurent2	ROHIM [54]	4.59	102	24	-3.4
	NMHE [77]	6.15	42	77	6.07
	Proposed	6.17	23	92	6.17

Chapter 5

CONCLUSION AND FUTURE WORKS

5.1 CONCLUSION

The technique NMHE is a good technique it improve the contrast but there is a drawback that when it improve the contrast then image become little dim after contrast enhancement. We also observe that in this technique there is little noise injection in the contrast enhanced image. Hence NMHE did not overcome the problem of noise in image and its brightness.

The other previous technique is ROHIM, it observe that the images which are enhanced by this technique become overly bright, which creates difficulties for reading of the images. Enhanced images become too much bright so that few features of that image become invisible.

The proposed method fused the objective and subjective quality assessment for contrast. So in assessment of the above mentioned methods proposed method preserve the details of the image and also avoid the artifacts which are normally produce in previous techniques. our proposed model enhanced the contrast of the image of more suitable luminous and glossier than the existing techniques.

5.2 FUTURE WORK.

Since proposed technique works well for the removal of artifacts and for contrast enhancement. Image enhancement has application in many other fields like aerial imaging, satellites images, digital cameras, picture remote sensing applications, forensic labs, fingerprints and face recognition etc. These image enhancement techniques are very important tool for highlighting areas to improve the visual representation of the picture. It has a considerable application in medical imaging like in MRI, ultrasound and X-Rays.

In future our proposed method can be implemented in video processing. In video there are number of frames, so our method should be applied to each frame and the contrast must be enhanced in each frame individually. To get a video sequence all the frames are combined. Execution time is the major factor for the video processing.

This thesis completely analyses the fact that there still few improvements are required in existing techniques to give better results.

Some recommendations for the future work are

- The phenomenon hazing is a natural phenomenon in the outdoor images, so to remove this haze effect and still need further research.
- Blocking effects on the images which have very low bit rate still need some improvement and further research for deblocking area.
- To explore more better techniques and model for contrast enhancement..
- Image enhancement has future scope in forest mapping classification techniques, forensic, astrophotography, fingerprint matching etc. so to meet these approaches we requires further research in our work.

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