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A Hybrid Method for Contrast Enhancement with Edge Preservation of Generalized Images

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Abstract— **Image enhancement becomes most important technique in digital image processing because everyone wants lovely looking images. Many techniques have been discovered from last few years to improve the visual appearance of the images. For better visualization of dark looking images or contrast limited images, a hybrid approach for contrast enhancement and edge preservation is developed. This approach not only enhanced the contrast of images but the edges, corners, boundaries of images are also getting preserved. Since edges of image contain rich information, thus it becomes very necessary to preserve the edges of image. To achieve this challenging task, a hybrid approach of histogram equalized image, modified gamma corrected image and original test image is developed. For the detection of preserved edges, edge detection method is used. For checking the effectiveness of this novel approach, four performance parameters are computed i.e. Discrete Entropy (H), Absolute Mean Brightness Error (AMBE), Mean Square Error (MSE), and Peak Signal to Noise Ratio (PSNR). Maximum value of Entropy and PSNR, Minimum value of MSE and AMBE are preferable. Novel approach of contrast enhancement with edge preservation fulfills all these demands.**

Index Terms— **Contrast enhancement, Edge preservation, Edge detection, Histogram equalization, Modified gamma correction.**

I. INTRODUCTION

Image enhancement plays a vital role in the image analysis and interpretation of remotely sensed data. Especially data obtained from satellite, remote sensing, biomedical, which are in the digital form. It helps in maximizing clarity, visibility, sharpness and other properties which are necessary for extracting the information by image analysis and recognition. (a) Contrast enhancement, (b) Intensity, hue, and saturation transformations, (c) Density slicing, (d) Edge enhancement (e) Making digital mosaics, (f) Producing synthetic stereo images are some examples of image enhancement operations. Contrast enhancement is one of the most commonly used technique for image enhancement. Contrast enhancement techniques [1] can broadly be classified into two categories: direct and indirect methods. In direct methods the image contrast can be directly defined by a specific contrast term. On the other hand indirect methods improve the contrast without defining a specific contrast term. In other words it enhances contrast of the image by redistributing the probability density function. Histogram modification is the greatly used technique which comes under the indirect contrast enhancement method because it consumes less computation time and also easy to perform. Histogram equalization and Gamma correction are one of the techniques which falls under histogram modification technique. Histogram Equalization (HE) is a technique that made contrast adjustment using histogram of image. Histogram is the discrete function. Discrete form of histogram equalization is formulated as $s_k = T(r_k)$ where T is the transformation matrix, r_k is the input image and s_k is the intensity value of output image. It allocates the pixel values evenly so that producing the resultant picture better. There are many methods by which Histogram of an image can be equalized. A histogram simply plots the frequency at which each grey-level occurs from 0 (black) to 255(white). Many methods have been introduced to enhance the contrast of images. In Classical Histogram Equalization (CHE) given number of gray levels over a range is uniformly distributed. The CHE produce a resultant image with a flattened histogram, when compared to that of input image. An image is made by the dynamic range of gray level values. Basically, the entire gray level values i.e. intensity of image are denoted as 0 to L−1. The problem associated with this method is that while enhancing the contrast of its background, the signal gets distorted and produces undesired changes. It produces unrealistic and unlikely effects in photographic images. In Adaptive Histogram Equalization the contrast of the image is enhanced by transforming the values in the intensity image. It overcomes the limitations of global linear min-max windowing and global histogram equalization by providing most of the desired information in a single image which can be produced without manual intervention [2]. But it introduced a problem of over-amplifying noise in some homogeneous regions of an image. Also at the same time it is not efficient to retain the brightness with respect to the input image. The remedy of these problems is an advanced and modified version of AHE which is known as Contrast Limited Adaptive Histogram Equalization (CLAHE). Brightness preserving Bi-Histogram Equalization (BBHE) is a technique in which two separate histograms from the same image is obtained and then equalized independently. Where first one is the histogram of intensities that are less than mean intensity, and second one is the histogram of intensities that are greater than mean intensity. This method can reduce the mean brightness variation [3]. Recursive Mean Separate Histogram Equalization (RMSHE) [4] which enhances an image by iterating BHE. The mean intensity of the output image will converge to the average brightness of the original image when the iteration increases and hence the brightness of the enhanced image to the original image can be maintained far better. Although the methods mentioned above can often increase the contrast of the image, these approaches usually bring some undesired effects. Overall the traditional global histogram equalization (GHE) will cause excessive enhancement, and the local histogram equalization (LHE) introduces block effect [5].

The edges of image contain large amount of information that is very important for obtaining the image characteristic by

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object recognition. It plays an important role in image understanding and image analyses, thus it is very important to preserve edges of image during contrast enhancement. Many methods are developed to preserve the edges of image which are based on local linear kernel surface estimation [6]. Other methods are based on mean shift by nonlinear filtering [7]. The edge-preserving filter is used to generate a good mask which smooths the image area with clear and fine details. Enhanced sharpness of edges is also one of the feature required in image enhancement tasks [8]. The halftoning method which is based on modified nasik pattem techniques reduces visible quantization errors and maintains image texture simultaneously. Not only the edges in luminance domain but the boundaries in chrominance domain are also preserved [9]. Edge preserving image enhancement by harmony search technique boosts the relative number of edges in the image. It also improves the entropic measure of the images and enhances the overall intensity level of edges as well. The problems associated with it are increased complexity and computational time [10].

Edge detection is one of the most commonly used techniques to detect preserved edges of images. It is a fundamental tool which is usually used in many image processing applications to obtain information from images and frames and this method is also suitable to find the discontinuities in depth, discontinuities in surface orientation, changes in material properties, features detection, features extraction and variations in scene illumination [11]. Different methods of edge detection technique are Sobel edge detector, Robert edge detection, Prewitt edge detection, Laplacian of Gaussian (LOG), Canny Edge Detector. The rest of this paper is organized as follows: Section II provides a detail of proposed method. Section III provides the details of performance parameters. In Section IV, Results are computed and performance parameters are compared with the help of charts. Section V includes the conclusion and future scope of proposed method.

II. PROPOSED METHOD

It has been seen that image enhancement are one of the major research issues in today's world because everyone wants good quality picture. Most of methods discussed above are too complex to implement and also not provide an efficient approach for contrast enhancement and edge preservation because traditional global histogram equalization causes excessive contrast enhancement while local histogram equalization causes block effect. Losses of edges of image when two nearby pixels have same or approx same grey level value (i.e. intensity value) is also a big problem occurs during image enhancement. Mixing of pixels occurs in an image due to over enhancement & under enhancement and hence information loss is the result. To overcome all these problems a hybrid approach is developed for image enhancement that provides an efficient result to almost all the images. It will not only enhance the contrast of the images but also preserved the edges of image which can be detected by edge detection methods.

Histogram equalization and modified gamma correction [12] of images are computed. Histogram equalization of image is represented as

$s_k = T(r_k)$ (1)

where T is the transformation matrix, r_k is the input image and s_k is the intensity value of output image. Modified gamma correction is formulated as follows:

$T(l) = l_{max}(l/l_{max})^{\gamma}$ (2)

Where γ = 1-cdf (l), γ denotes gamma value and l_{max} is the maximum intensity of the input. After this, hybridization of input image, histogram equalized image and modified gamma corrected image is carried out which results in contrast enhancement with edge preservation of input image. The hybridization technique is based on summation of original image, weighting coefficient k multiplied by histogram equalised image, weighting coefficient λ multiplied by modified gamma corrected image and then whole is divided by summation of 1, k and λ. Edge detection filtration method detects the preserved edges obtained in final image by hybridization technique. Since intensity value of image contains many discontinuities which contains meaning full data, therefore the need of edge preservation of images are experienced. Such discontinuities are detected by first and second order derivatives. The first order derivative in image processing is gradient. The gradient is defined as the vector i.e. $\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix}$. The magnitude of this vector is represented as

∇f = mag (∇f) = $[G^2_x + G^2_y]^{1/2}$
= $[(\partial f/\partial x)^2 + (\partial f/\partial y)^2]^{1/2}$ (3)

Where G_x and G_y are first order derivatives. Second order derivatives in image processing is usually obtained by laplacian which is represented as

$\nabla^2 f(x,y) = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2}$ (4)

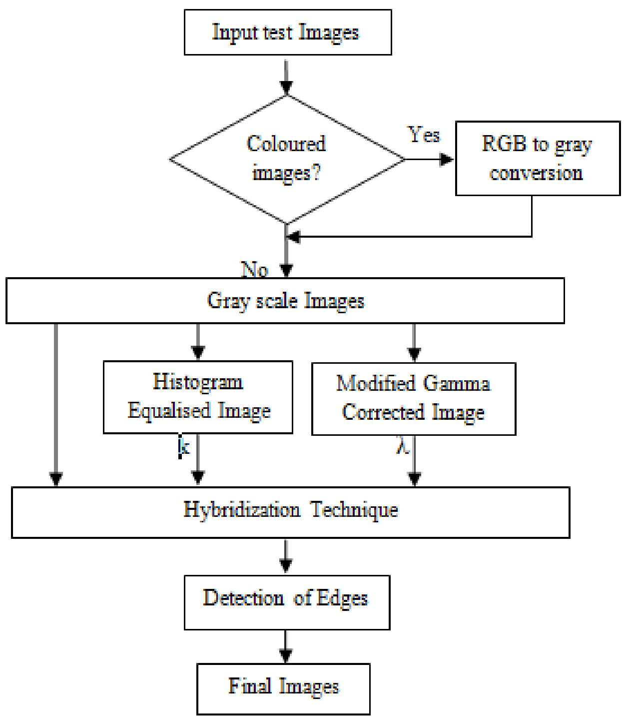


Figure :1 Flow Chart of proposed method

III. PERFORMANCE PARAMETERS

Image Enhancement performance parameters in the term of Entropy, Absolute Mean Brightness Error (AMBE), Mean

Square Error (MSE), and Peak Signal to Noise Ratio (PSNR) are computed which justify the proposed method. Here three test images are considered and proposed method is applied on them one by one and then parameters mentioned above are computed and comparison graph are plotted which will be shown in results section. Higher the value of Discrete Entropy (H), higher the information contents in image. It is formulated as $H(X) = \sum_i P(xi)\, I(xi) = -\sum_i P(xi) \log P(xi)$ (5)

Lower the value of AMBE, higher the preservation of mean brightness of images.

$$AMBE = 1/N \sum_{i=1}^{l} |E(X) - E(Y)| \quad (6)$$

where N represents the total number of test images, E(X) and E(Y) are the average intensity of N^{th} test images, and E(Y) the average intensity of the corresponding output images. Lower the value of MSE, higher is the preservation of edges of image.

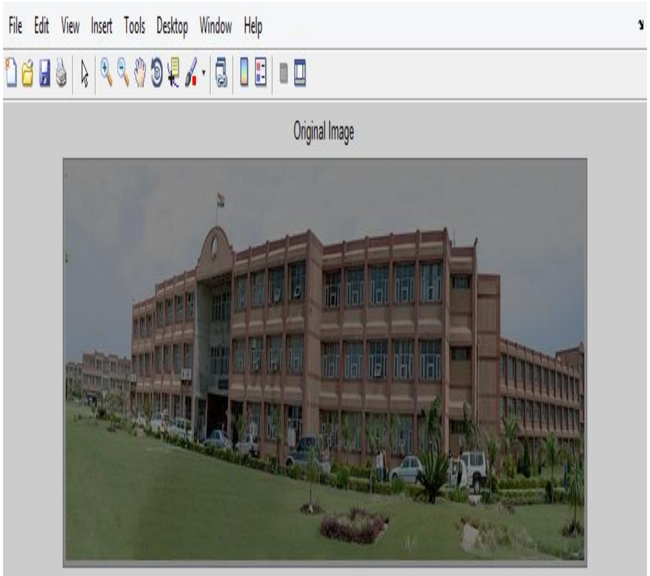
It is formulated as

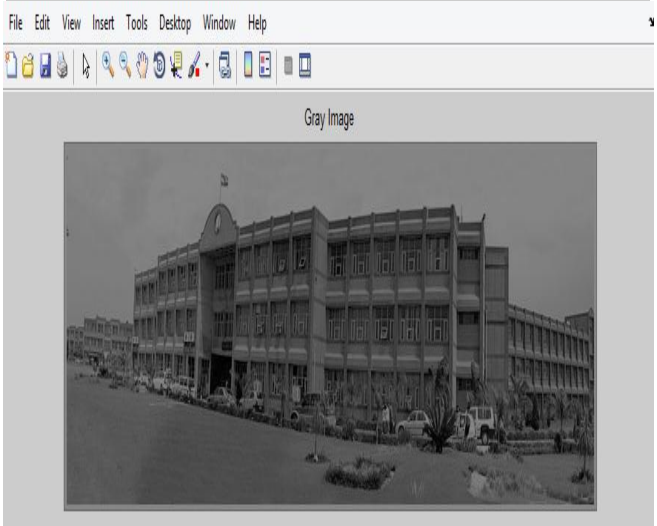
$$MSE = \frac{1}{N} \sum_i \sum_j (X_{ij} - Y_{ij})^2 \quad (7)$$

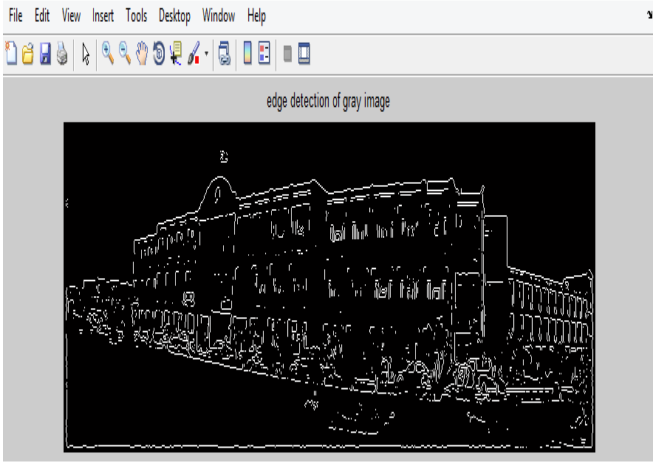
Where N is the size of image X is the processed image and Y is the input image. Larger the value of PSNR, better the quality of images. It is formulated as

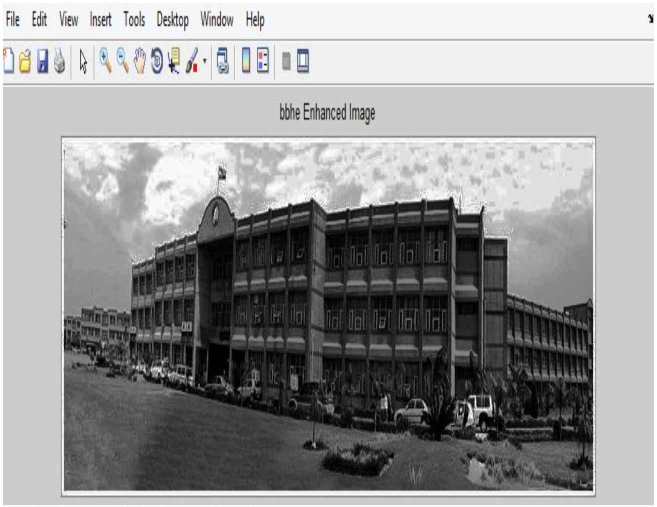
$$PSNR = 10 \log_{10} \left(\frac{255^2}{MSE\ equalised\ image} \right) \quad (8)$$

IV. EXPERIMENTAL RESULTS AND ANALYSIS









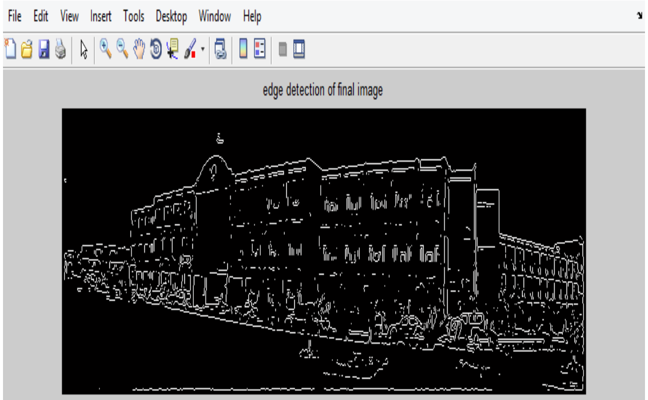
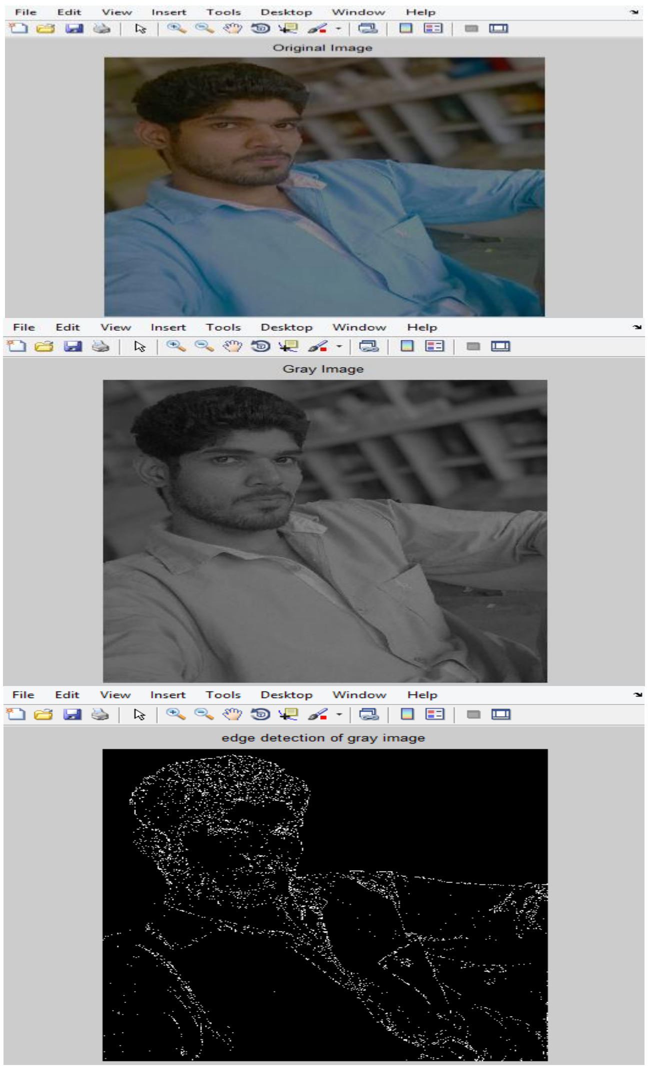


Figure:2 (a) Original Image (MMU campus) (b) Gray scale of original image (c) Edge Detection of Gray Image (d) Histogram Equalized Image (d) BBHE Image (e) Final Image (f) Edge Detection of Final Image

Table: 1 shows the experimental results for figure 2

MMU CAMPUS	ENTROPY(H)	AMBE	MSE	PSNR
Histogram Equalised Image	5.65	39.91	61.52	30.3
BBHE Image	6.25	13.1	248.26	24.22
Final Image	**5.71**	**2.8**	**8.1**	**39.06**



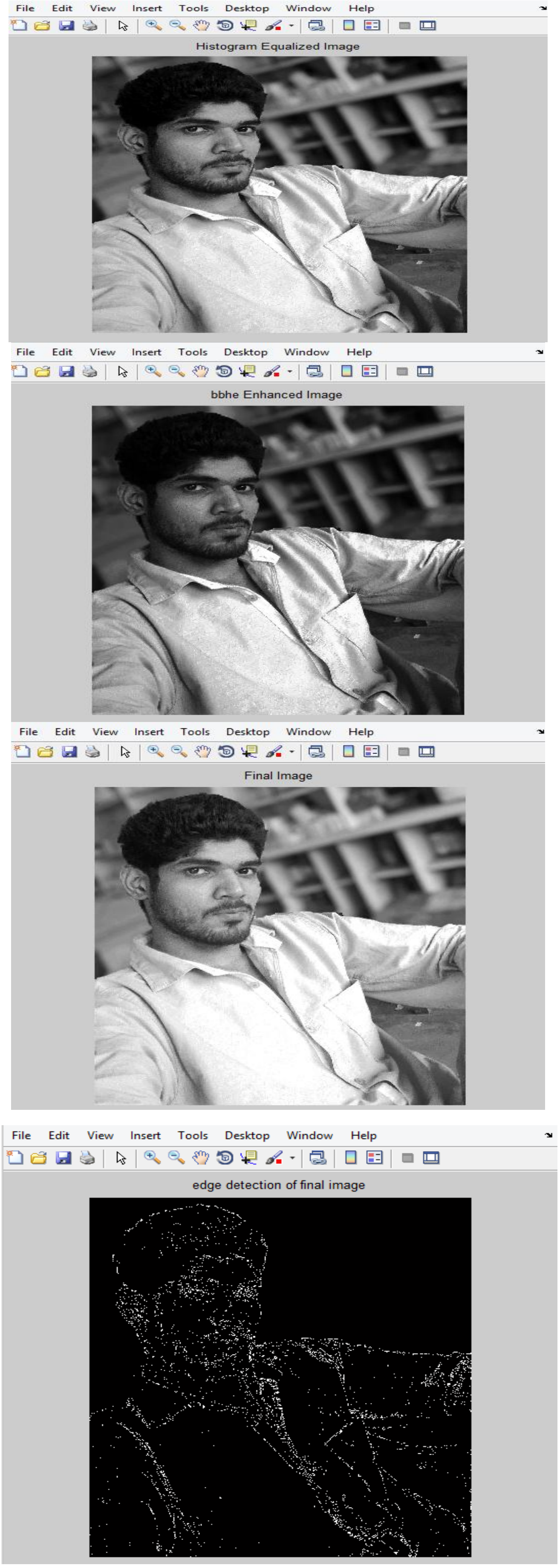
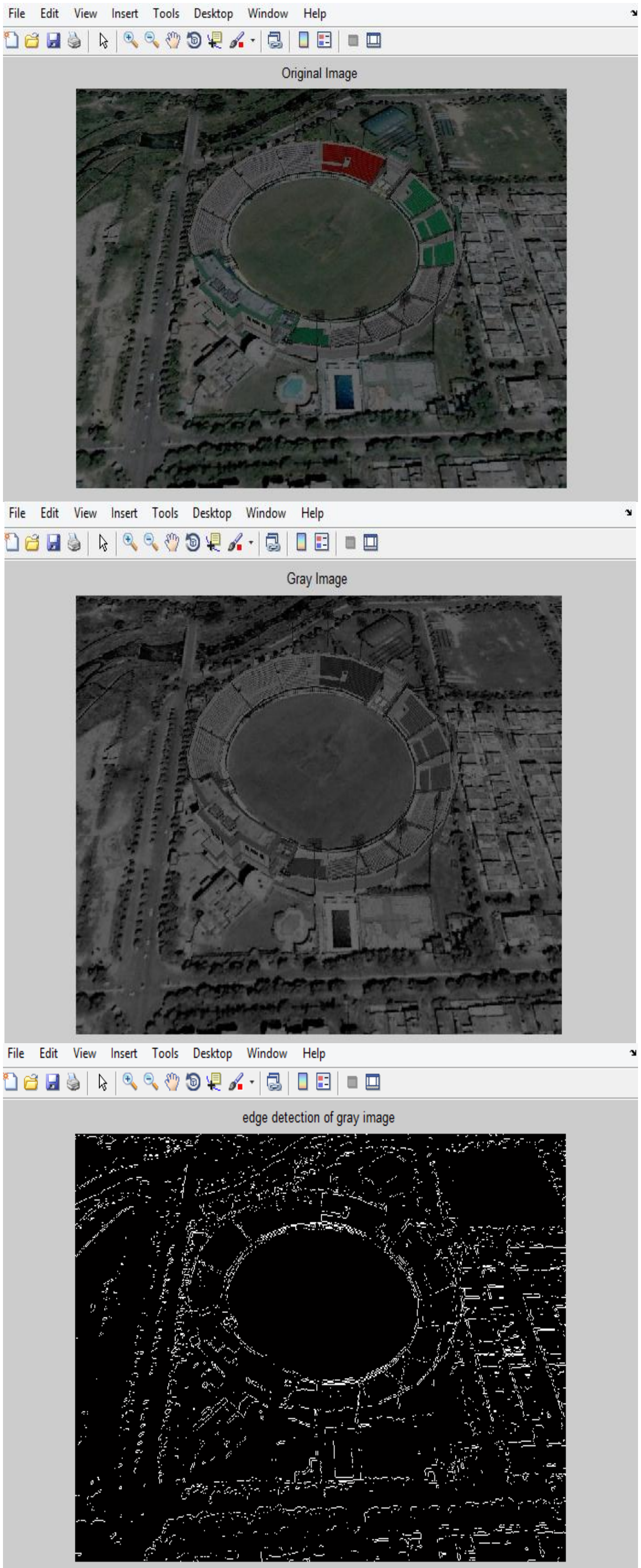


Figure:3 (a) Original Image (shubham's selfie) (b) Gray scale of original image (c) Edge Detection of Gray Image (d) Histogram Equalized Image (d) BBHE Image (e) Final Image (f) Edge Detection of Final Image

Table: 2 shows the experimental results for figure 3

Shubham's selfie	ENTROPY (H)	AMBE	MSE	PSNR
Histogram Equalised Image	5.85	47.1	48.3	31.33
BBHE Image	6.5	28	146.6	26.50
Final Image	**6.01**	**7.5**	**6.55**	**40.00**



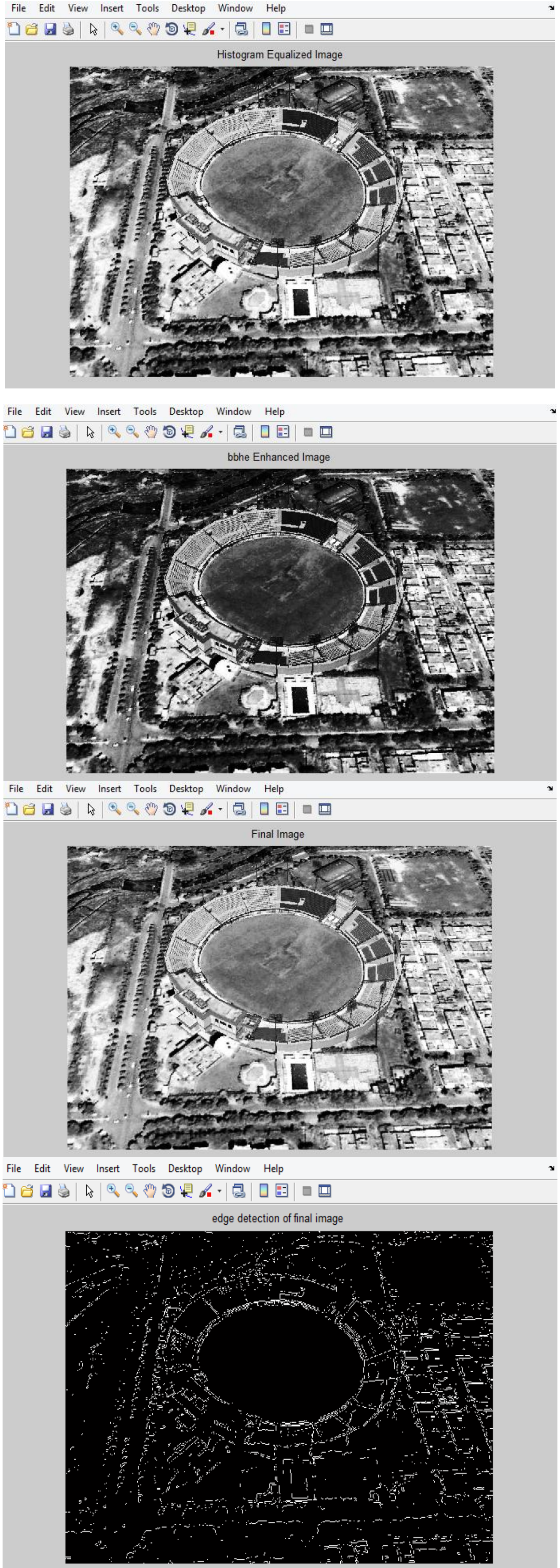


Figure:4 (a) Original Image (satellite view of PCA cricket stadium) (b) Gray scale of original image (c) Edge Detection of Gray Image (d) Histogram Equalized Image (d) BBHE Image (e) Final Image (f) Edge Detection of Final Image

Table: 3 shows the experimental results for figure 4

PCA Cricket Stadium	ENTROPY(H)	AMBE	MSE	PSNR
Histogram Equalised Image	5.78	69.7	0.26	54.1
BBHE Image	6.22	37	77.2	29.3
Final Image	**6.3**	**18**	**0.05**	**61.5**

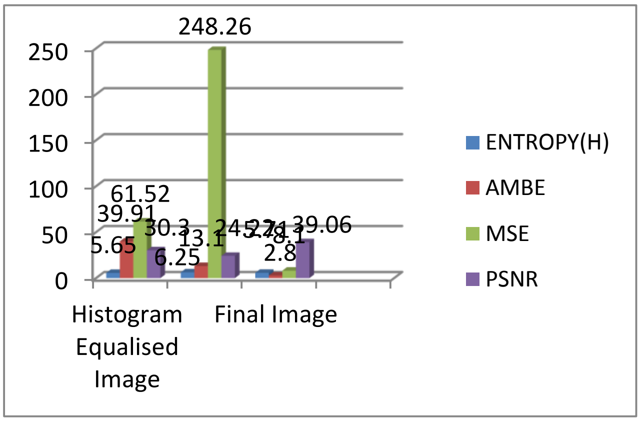


Figure : 5 Comparison Chart of Proposed Method with Histogram Equalization and BBHE method for figure 2

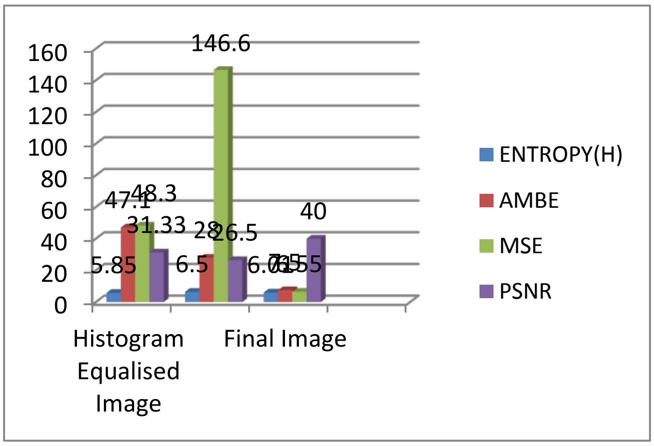


Figure : 6 Comparison Chart of Proposed Method with Histogram Equalization and BBHE method for figure 3

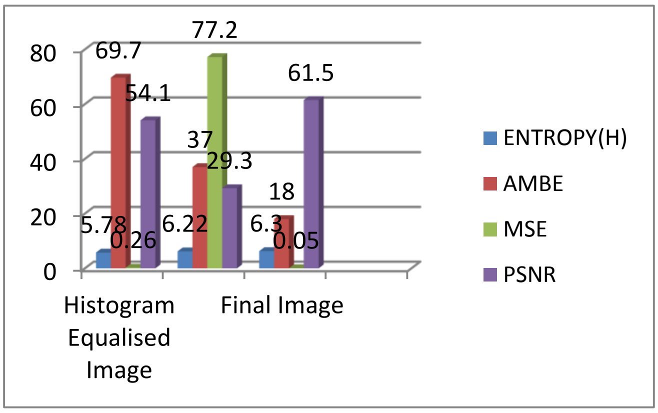


Figure : 7 Comparison Chart of Proposed Method with Histogram Equalization and BBHE method for figure 4

In this section, results and performance parameters of three images are carried out and it is clearly seen that performance parameters of proposed method are better than rest of two i.e. Histogram Equalization method and BBHE method. Proposed method gives maximum Entropy and PSNR, minimum MSE and AMBE which can be seen in charts shown above.

V. CONCLUSION AND FUTURE SCOPE

An efficient image enhancement method is proposed which is based on hybridization of original image, histogram equalized image and modified gamma corrected image that will not only enhance the contrast of images but also preserve the edges of images. Edge detection helps to detect preserved edges of enhanced images. The problems of losses of edges due to over or under enhancement, block effects, excessive contrast enhancement caused by local histogram and global histogram respectively are solved by hybrid approach. This novel method improves the clarity and visibility of images which are the major need in image processing, remote sensing and biomedical images. This method can be applied to enhanced the SAR images, Satellite images and medical images.

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