Low Contrast Color Image Enhancement by Using GLCE with Contrast Stretching

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***Abstract*— The principal objective of enhancement techniques is to process an image so that the result is more suitable than the original image for a specific application. Image enhancement techniques used in many areas such that Forensics, Astrophotography, Fingerprint matching etc. In image processing, low contrast image analysis is a challenging problem. Low contrast digital images reduce the ability of observer in analyzing the image. Here we propose a new method for low contrast color images enhancement. This method uses two step processing, in first step global contrast stretching method is applied to improve the contrast of image and then in second step global and local contrast enhancement(GLCE) is performed because applying the local contrast enhancement along with global contrast enhancement is much better than that of global contrast enhancement only or local contrast enhancement only. To evaluate the effectiveness of our method we choose two widely used metrics Absolute Mean Brightness Error (AMBE) and PSNR. Based on results of these two metrics this algorithm is proved as a flexible and effective way for low contrast image enhancement.**

***Index Terms*—Contrast, GLCE, Image Enhancement**

I. INTRODUCTION

Image enhancement is a process of improving the quality of image by improving its feature. Image enhancement is a method of digital image processing which processes the digital image. Image enhancement includes contrast and edge enhancement, feature sharpening and noise filtering and so on. Among these technique contrast enhancement is important because human eyes are more sensitive to the luminance than to the chrominance/color component of an image. Principle of Contrast enhancement is to improve the visual appearance of the image without introducing unwanted effects and artefacts. Various images like medical images, aerial images, satellite images and even real life photographs may suffer from noise and poor contrast due to the inappropriate lighting during image acquisition and/or wrong setting of aperture size and shutter speed of a camera, so it is necessary to enhance the contrast and remove the noise to increase image quality. Application area of image enhancement ranges from medical images to real life photography. Contrast enhancement is one of the challenging and interesting areas of image processing [1].

Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. It is often used to increase the contrast in images that are substantially dark or light. Image enhancement entails operations that improve the appearance to a human viewer, or operations to convert an image to a format better suited to machine processing. Image enhancement refers to those image processing operations that improve the quality of input image in order to overcome the weakness of the human visual system [2].

To understand to concept of image enhancement let we denote a two-dimensional digital image of gray-level intensities by I. The image I is ordinarily represented in software accessible form as an M × N matrix containing indexed elements I(i, j), where $0 \leq i \leq M - 1$, $0 \leq j \leq N - 1$. The elements I(i, j) represent samples of the image intensities, usually called pixels (picture elements). For simplicity, we assume that these come from a finite integer-valued range. This is not unreasonable, since a finite word length must be used to represent the intensities. Typically, the pixels represent optical intensity, but they may also represent other attributes of sensed radiation, such as radar, electron micrographs, x rays, or thermal imagery.

Image enhancement is applicable in every field where images are to be understood and analyzed like medical image analysis, satellites images analysis etc. we can say that Image enhancement simply means, transforming an image I into image J using T (see figure 1). Where T is the transformation. The values of pixels in images I and J are denoted by p and q, respectively. As said, the pixel values p and q are related by the expression [3-4],

$$q = T(p) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where T is a transformation algorithm that maps a pixel value p into a pixel value q . The results of this transformation are mapped into the grey scale range or color image. if we are dealing with grey scale digital images. Then, the results are mapped back into the range [0, L-1], where L=2k, k being the number of bits in the image being considered. So, for example, for an 8-bit image the range of pixel values will be [0, 255]. The same theory can be extended for the color images too [3-4].

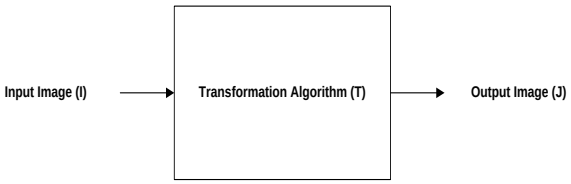

Fig. 1. Image Enhancement Operation

II. IMAGE ENHANCEMENT TECHNIQUES

There exist many techniques that can enhance a digital image without spoiling it. Image enhancement improves the quality (clarity) of images for human presentation. Eliminating blurring and noise, increasing contrast, and enlightening details are examples of enhancement operations. For example, an image might be chosen of an endothelial cell, which may be of low contrast and little blurred. Decrementing the noise and blurring and incrementing the contrast range could enhance the image.

Basically, Image enhancement is classified into two broad categories namely frequency domain, and spatial domain and fuzzy domain methods. In the frequency domain method, the enhancement is conducted by modifying the frequency transform of the image. Meanwhile in the latter method image pixels are directly modified to enhance the image. However, computing the enhancement in frequency domain is time consuming process even with fast transformation technique thus made it unsuitable for real time application [5].one of the latest method that is gaining popularities to enhance the image is fuzzy technique which is based on gray level mapping into fuzzy membership function. In these technique fuzzy set rules is used to modify the membership function. and finally defuzzification is applied to enhance image.

So we can say that Image enhancement techniques can be divided into three broad categories:

Spatial domain methods.

Frequency domain methods (DFT).

Fuzzy Domain.

Spatial domain techniques directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. Spatial domain techniques like the logarithmic transforms, power law transforms, histogram equalization are based on the direct manipulation of the pixels in the image. Spatial techniques are particularly useful for directly altering the gray level values of individual pixels and hence the overall contrast of the entire image. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results. It is not possible to selectively enhance edges or other required information effectively [6].

Frequency domain techniques are based on the manipulation of the orthogonal transform of the image rather than the image itself. Frequency domain techniques are suited for processing the image according to the frequency content. The principle behind the frequency domain methods of image enhancement consists of computing a 2-D discrete unitary transform of the image, for instance the 2-D DFT, manipulating the transform coefficients by an operator M, and then performing the inverse transform.

Fuzzy image enhancement is based on gray level mapping into membership function. The aim is to generate an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image that are farther from the mean [7-8].

III. LITERATURE SURVEY

Many contrast enhancement algorithms are existing, but development of new algorithm which would produce better images than the existing one is a challenging problem. Several algorithms have been proposed to overcome the uncertainties encountered during transmission and acquisition of the images. Sometimes these uncertainties or vagueness are caused by low contrast in the images. So it is necessary to represent and resolve uncertainty effectively to improve the contrast. Because of the ability to handle and manage the imprecision encountered with images effectively, applying GLCE becomes a strong in road image processing areas like contrast enhancement. Many research works are still going on in this area to make improvements in the existing techniques.

A. Contrast Enhancement Algorithm for Colour Images

In 2015 Solomon j.A. ojo and S.A. Adeniran proposes a contrast enhancement technique to enhance colour images captured under poor illumination and varying environmental conditions. Images are converted from RGB to HSV colour space where enhancement is achieved and reconverted to the RGB. Class Limited Adaptive Histogram Equalization (CLAHE) is used to enhance the luminance component (V). Discrete Wavelet Transform is applied to the Saturation (S) components, and the decomposed approximation coefficients are modified by a mapping function derived from scaling triangle transform. The enhanced S component is obtained through Inverse Wavelet transforms. The image is then converted back to the RGB colour space. Subjective (visual quality inspection) and objective parameters (Peak-signal-to-noise ratio (PSNR), Absolute Mean Brightness Error (AMBE) and Mean squared error (MSE)) were used for performance evaluation. The algorithm implemented in MATLAB was tested images and compared with outputs of HE and CLAHE enhancement techniques. The result shows that the new algorithm gave the best performance of the three methods [9]..

B. A Combined Effect of Local and Global Method for Contrast Image Enhancement

In 2015, Sampada S Pathak et.al. [10] suggests a combination of local and global method for contrast image enhancement. Global contrast image enhancement improves low contrast of image in a global way. This type of global enhancement avoids noise and other ringing artifacts of a

digital image. In global contrast image enhancement when high contrast occurs it causes under exposure on some part of image and over exposure on some other part of an image. Global contrast image enhancement has much advantage but it lack in local enhancement of image means it lacks the local detail of an image. When we use local detail of an image, the local detail of an image can be defined in better way. Local contrast image enhancement increases noise of an image when high contrast gain occurs. When we use global contrast image enhancement or local contrast image enhancement single handedly it is not beneficial but when we use combination of local and global method it gives us better results for certain images. In this paper authors will going to use global contrast stretching method for global contrast image enhancement .In local contrast image enhancement method we are using unsharp masking technique to enhance the local detail of an image. The main aim of using this combination of local and global method is to preserve the brightness of an image when contrast image enhancement is done.

IV. PROPOSED METHODOLOGY

Image enhancement task such contrast enhancement, edge enhancement, noise filtering etc. all these tasks includes some kind of uncertainties such as grayness ambiguity, geometry/spatial ambiguity and uncertain knowledge. Among these tasks contrast enhancement is more important because human eyes are more sensitive to luminance than to color/chrominance. Many contrast algorithms are developed but the exiting algorithms do not handle the uncertainties or vagueness caused by the low contrast in the image. These uncertainties can be encountered during the transmission or acquisition of image. In many cases these uncertainties are caused by the low contrast of the image. Therefore, it is necessary to represent and resolve the uncertainty present in the images. In addition to these, shortcomings of the existing contrast enhancement techniques also suffer from over-enhancement and under-enhancement.

Our proposed methodology uses the global and local contrast based image enhancement technique for contrast enhancement. The steps of our proposed methodology are given in the subsequent sections.

A. Input Image

In our method, first of all input image is taken for the enhancement. Our method takes 24-bit input image X of M×N×3 size. This method takes the low contrast color images.

B. Color plane based Contrast Stretching

To perform color plane based contrast image enhancement method we are using global contrast stretching method. Global Contrast stretching is a simple image enhancement technique that changes the range of pixel intensity values. This method enhances the pixel intensity into desired range.

C. Global-Local Contrast Enhancement (GLCE)

GLCE method can be implemented as follows. using following eq.:

$$f_x(i,j) = (1+C_g)*[x(i,j) - g_{mean}] + 0.5$$

where, x(i,j) is the pixel value at location (i,j) of the original input image, Cg is the global contrast gain control, gmean is the global mean of the pixel values of the whole image and the threshold too and fx(i,j) is the enhanced value of the pixel x(i,j).

Then applying following equation on the output values given as,

$$f(i,j) = f_x(i,j) + \frac{C}{\sigma(i,j)+s}.[f_x(i,j) - m(i,j)]$$

where, fx(i,j) is the globally enhanced output value of the original pixel value x(i,j) at location (i,j) of the original input image ,m(i,j) is the local mean at (i,j) among the neighbourhood values of fx(i,j),σ(i,j) is the LSD at (i,j) among the neighbourhood values of fx(i,j), C is the local contrast gain control, s is very small and negligible quantity greater than zero and f(i,j) is the enhanced output value produced by GLCE.

Figure 2 shows the block diagram of proposed method.

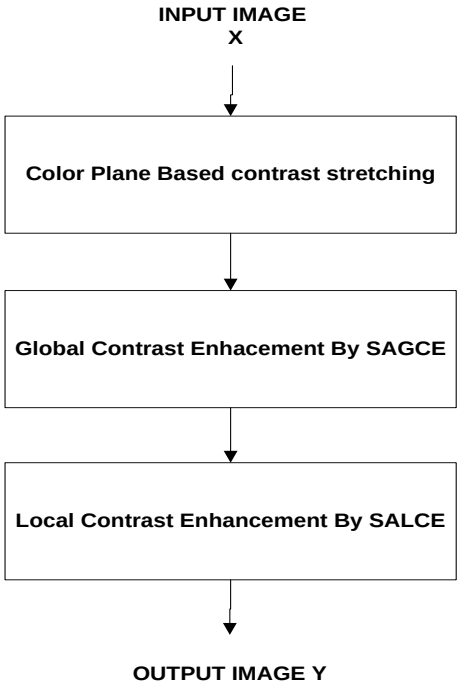

Fig. 2. Block diagram of the proposed image enhancement system working

V. PARAMETER MEASUREMENT

Every above method are compared by statistical point of view by using some standard quality measures

A. Peak-signal-to-noise-ratio (PSNR):

PSNR is the evaluation standard of the reconstructed image quality, it is generally used in measuring the quality and it is important measurement feature. PSNR is measured in decibels (dB) and is given by [12]:

$$PSNR = 10 \log 255^2 / MSE$$

Where the value 255 is maximum possible value that can be attained by the image. MSE is Mean square error and it is defined as error between two images. Higher the PSNR value is, better there constructed image [10].

B. Absolute mean brightness error (AMBE):

Absolute Mean Brightness Error is used to assess the degree of brightness preservation .It is calculated using the equation as [11].

$$AMBE = |E(x) - E(y)|$$

Where, E(x) is the mean of the input image, E(y) is the mean of the output image. A median value implies better brightness preservation [10].

VI. Experimental Performance

In this section, we demonstrate the performance of the proposed method in comparison with some existing contrast enhancement methods. The enhanced image is analyzed in terms of its output quality and quantitative analysis such as Absolute mean brightness error (AMBE), peak signal to noise ratio (PSNR).

The enhanced images produced by the proposed methods are presented in Figures 3 to 5 . For the subjective qualitative analysis of processed image appearance. The original images have poor brightness in the underexposed regions and brightness is higher in the overexposed regions.

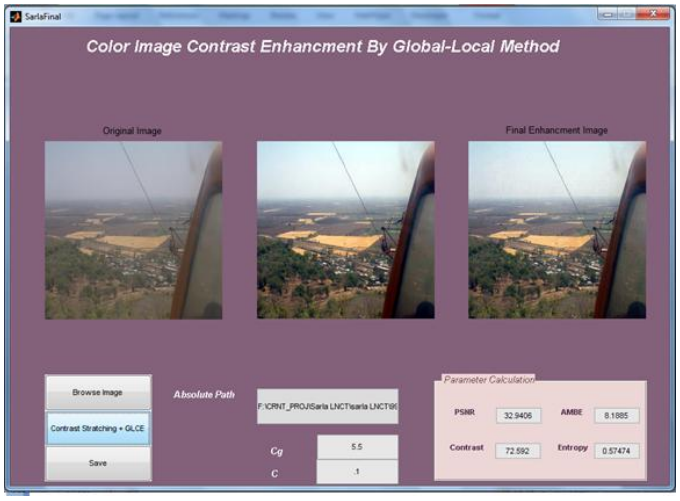

Fig. 3. (a) original image (test image 1), (b) enhanced image with Contrast Stretching (c)Final Enhanced image by proposed method

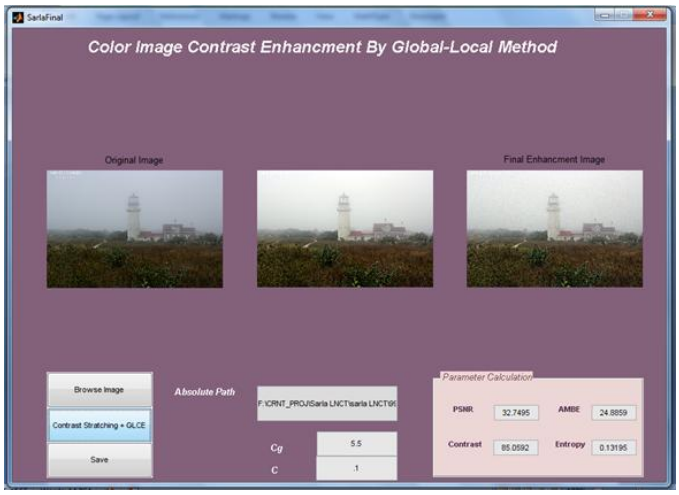

Fig. 4. (a) original image (test image 2), (b) enhanced image with Contrast Stretching (c)Final Enhanced image by proposed method

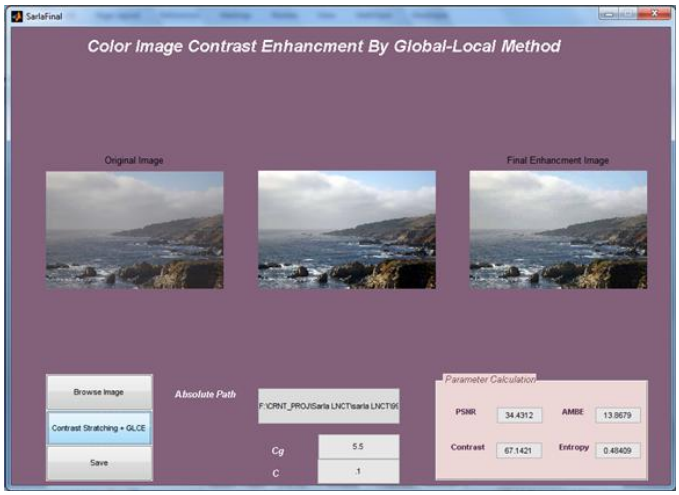

Fig. 5. (a) original image (test image 3), (b) enhanced image with Contrast Stretching (c)Final Enhanced image by proposed method

In order to demonstrate the performance of the proposed method, we compared qualitatively and quantitatively the experimental results of the proposed approach with other state of the art methods namely HE , CLAHE , and CEACI are widely used in image enhancement.

Absolute Mean Brightness Error (AMBE)

Image Name	**HE**	***CLAHE***	***CEACI***	***Proposed***
test image 1	75.011	29.8414	22.2189	21.1562
test image 2	24.5108	24.0064	31.259	11.1165
test image 3	94.2895	24.5988	20.0706	10.4998
Average	64.6037	26.1488	24.5161	14.2575

Based on results of Table I, we observe that proposed has least values in all three images as compare to other methods. Further if we look at last row of Table I, which shows average

results of AMBE then we find that proposed method has least average AMBE values among other methods.

Table II shows results of PSNR values on given images by different methods.

PSNR

Image Name	***HE***	***CLAHE***	***CEACI***	***Proposed***
Shed	21.8927	30.1346	31.8385	32.5505
Satellite	21.8857	22.2622	23.4730	37.9007
Dark Imae	21.8931	36.3079	37.660	36.5667
Average	21.8905	29.5682	30.9905	35.6726

Based on results of Table II, a careful examination of the PSNR values reveals that our method produces comparatively better average PSNR values from that of HE , CLAHE and CEACI.

VII. Conclusion

The Proposed method provides optimum contrast enhancement while preserving the brightness of given low contrast image and suitable for all types of images. We used low contrast images for comparing our method with the existing other methods. Experimental results show that AMBE of the proposed method is less in comparison of other methods. Also PSNR of the proposed method is better from HE and is comparative with the CLAHE. On the basis of analysis of these two metrics shows that proposed preserves the input image brightness more accurately and gives processed image with better contrast enhancement

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