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Hue Preserving Low Contrast Image Enhancement Using Histogram Equalization and Contrast Stretching in DWT Domain and HSI color Model

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ABSTRACT
The main goal for image enhancement is to construct an image more suitable than the original image. Image enhancement techniques used in many areas such that Forensics, Astrophotography, Fingerprint matching etc. This paper presents a DWT based enhancement technique for low contrast color image. Proposed works transforms the RGB color image into HSI color model, then apply DWT on I component . After wavelet decomposition, histogram equalization is done just in LL frequency domain and then inverse DWT is applied. After getting the Enhanced I component, Contrast Stretching is applied on I. That will improve the intensity component globally. Besides this S component is also enhanced. Finally unmodified hue, modified Saturation and Intensity component is merged into HIS color model and HIS to RGB is applied. The proposed method gives better quality enhanced image and rather than the other methods.

Index Terms:-Image Enhancement, DWT, Contrast Stretching, HIS Color Model.

INTRODUCTION
Good contrast images with preserving details are required for many important areas namely machine vision, remote sensing, dynamic and traffic scene analysis, biomedical image analysis and autonomous navigation. However most of the recorded images suffer from poor contrast which is due to the inadequate lighting during image acquiring, wrong setting of aperture size and shutter speed as well as nonlinear image intensities mapping.

Difficulties in controlling the lighting conditions during image acquisition process have resulted in variability in image illumination. The captured images turn out to be low contrast and contained underexposed and overexposed regions. Thus, image enhancement has been employed to increase the quality of the image. Image enhancement is a fundamental task applied in image processing to improve interpretability and appearance of the image. It provides better input image for further image processing task [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 [3].

Image enhancement can be clustered into two groups namely frequency domain and spatial 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 [4].

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 this 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 set theory is thus useful in handling various uncertainties in computer vision and image processing applications. Fuzzy image processing is a collection of different fuzzy approaches to image processing that can understand, represent, and process the image. It has three main stages, namely, image fuzzification, modification of membership function values, and Defuzzification. 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].

III LITERATURE REVIEW

Many contrast enhancement algorithms are existing, but development of new algorithm which would produce better images than the existing one is a challenging problem. Many research works are still going on in this area to make improvements in the existing techniques.

A. Color Image Enhancement Based on Hue Differential Histogram Equalization

Janani Purushothaman et.al. [9] proposed a method to overcome disorder the differential gray-levels histogram equalization (DHE. In this paper, authors extend the DHE to color image processing. Then, hue and intensity information are taken into account for color image enhancement. Hue component is used for intensity processing. Even by keeping the intensity constant we can capture the edge by changing the hue. First the processing is done with intensity component and then with hue component. Finally intensity and hue component results are combined to produce better results. The proposed method has one parameter which controls the enhancement property of the color image. The guideline for the decision of the parameter which is agreed by the human sense is also described.

B. Color Image Enhancement Using Daubechies Wavelet Transform And HIS Color Model

Swati D. Nikam et.al. [10] proposed a method for enhancing the color image using wavelet transform in HIS color model. In this paper wavelet transform is used for color image enhancement. The proposed method enhances the contrast and luminance as well as removes the noise in the color image. In this proposed method daubechies wavelet transform and HIS color space used. By using daubechies wavelet trasform wavelet decomposition can be done on the component I. The wavelet transform is used to divide the image into four subbands. The edges are concentrated on HH, HL, LH, LL subbands. In enhancing the color image, it is important that hue should not change for any pixel. If hue is changed then the color gets changed, thereby distorting the image. In HIS color space I component is independent on other color channels.

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

Sampada S Pathak et.al [11] suggest a new technique for contrast image enhancement by a combination of local and global method. 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 They 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 They use global contrast stretching method for global contrast image enhancement .In local contrast image enhancement method they use 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

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.

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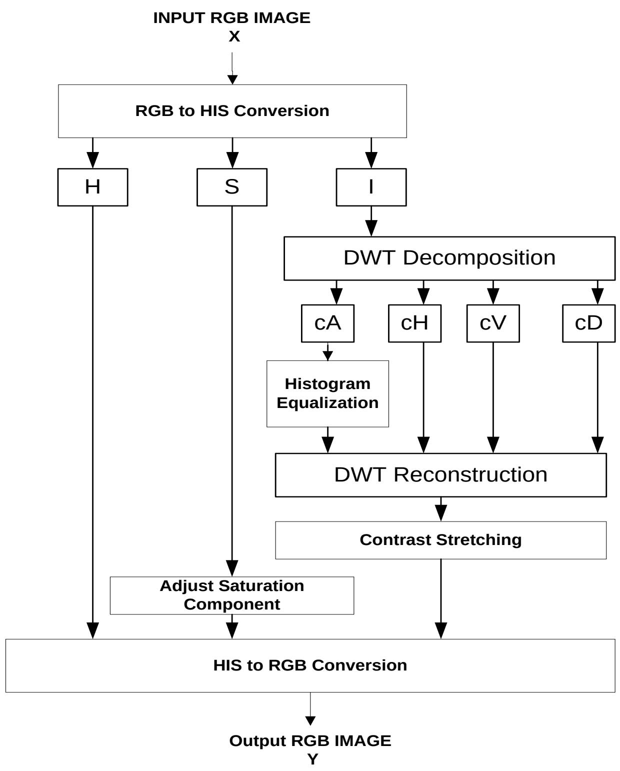

Figure 1: Block diagram of the proposed image enhancement system working.

D. 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.

E. RGB to HSI Conversion

The HSI color space is mostly used for image processing applications. In HSI color space I component is separated from H and S components. H and S components was closely related to the way that human perceives color [5].

In HIS color space H (hue) indicates the color purity, S (saturation) gives the contribution of white color in specific color and I indicate intensity [6]. HIS model is used in various applications such as computer graphics, human visual perception, image analysis, image editing, and computer vision and so on. Given an image X in RGB format, the intensity component I, saturation component S and hue component H are given as follows:

$$H = \theta, \text{ if } B \leq G$$
$$360-\theta, \text{ if } B > G$$

$$\theta = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-B)^2+(R-B)(G-B)^{1/2}]}\right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[MIN(R,G,B)]$$

$$I = \frac{1}{3}(R+G+B)$$

F. Wavelet Decomposition of I Component

By using daubechies wavelet transform wavelet decomposition can be done on the component I. The wavelet transform is used to divide the image into four sub-bands. The edges are concentrated on HH, HL, LH, LL sub-bands. In enhancing the color image, it is important that hue should not change for any pixel. If hue is changed then the color gets changed, thereby distorting the image. In HIS color space I component is independent on other color channels. So the wavelet decomposition is applied only to the I component. After wavelet decomposition, histogram equalization is done just in LL frequency domain.

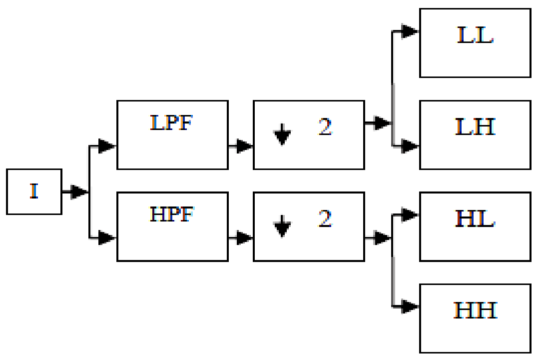

Figure 2: Wavelet decomposition of component I

G. Histogram Equalization

In this method, the histogram equalization is used to improve the image contrast. Histogram equalization is used to increase the dynamic range of the histogram of an image. Histogram equalization is done on LL sub-image of figure 3. The visual feeling of the general image is

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dependent on the low-frequency domain. On this point we can do histogram equalization just in low frequency domain. So the detail can avoid being blurred and the noise cannot be magnified if we just use the low frequency.

H. Wavelet Reconstruction

After wavelet decomposition and histogram equalization it is necessary to reconstruct the image without loss of information. The modified image is reconstructed by using inverse wavelet transform.

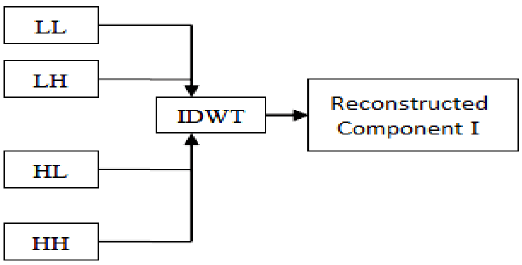


Figure 3: Wavelet Reconstruction.

I. Contrast Stretching

Global Contrast stretching is a simple point processing image enhancement technique that increases the dynamic range of image. It increases the contrast of the image by making the dark pixel more darker and bright pixel brighter.

After getting the Enhanced I component, Contrast Stretching is applied. That will improve the intensity component globally.

The formulation of the contrast stretching algorithm is given below.

$$I' = \begin{cases} L1.I & 0 \le I < x1 \\ L2.(I - x1) + y1 & x1 \le I < x2 \\ L3.(I - x2) + y2 & x2 \le I < 255 \end{cases}$$

Where, L1, L2 and L3 are the slopes. It is clear from the figure that L1 and L3 are less than one while L2 is greater than one.

J. S component enhancement

The purpose of the saturation adjustment is to make the color image more clearly. In this method, the saturation component is enhanced by mapping the values in S component by low_in and high_in map to values between low_out and high_out. Values for low_in, high_in, low_out, and high_out must be between 0 and 1.

K. HSI to RGB Conversion

Convert the final enhanced HSI color map back into the RGB color map [5] to obtain the enhanced image.

$$if\ RG \text{ section } (0^\circ \le H < 120^\circ)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$G = 1 - (R + G)$$

$$B = I(1 - S)$$

$$if\ GB \text{ section } (120^\circ \le H < 240^\circ)$$

$$R = I(1 - S)$$

$$G = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$B = 1 - (R + G)$$

$$if\ BR \text{ section } (240^\circ \le H \le 360^\circ)$$

$$H = H - 240^\circ$$

$$R = 1 - (G + B)$$

$$G = I(1 - S)$$

$$B = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

V PARAMETER MEASUREMENT

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

L. 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].

M. 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].

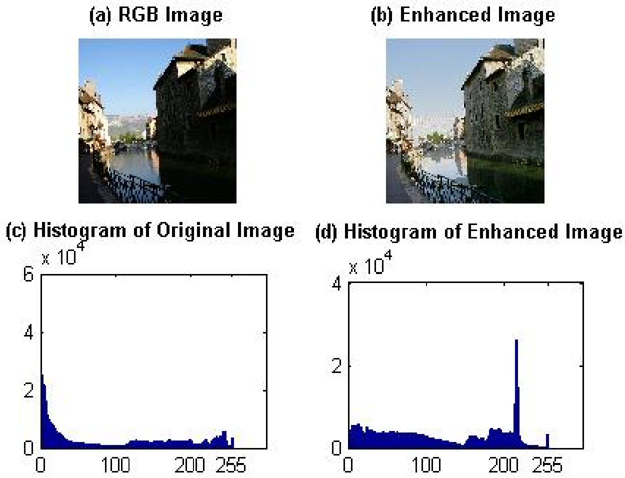
$$AMBE = |E(x) - E(y)|$$

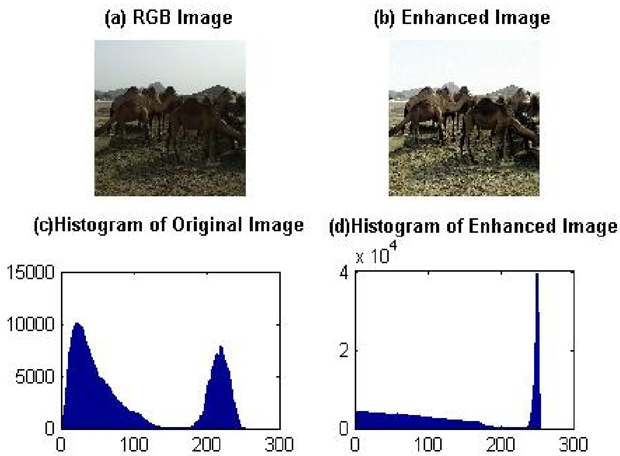
Where, E(x) is the mean of the input image, E(y) is the mean of the output image. A median value implies better brightness preservation [10].

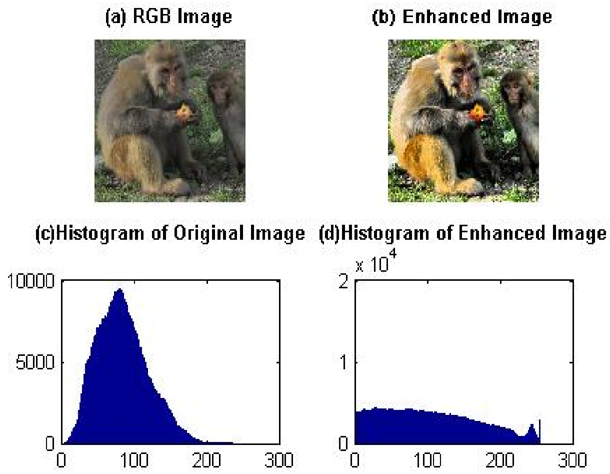
VI EXPERIMENTAL PERFORMANCE

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 4.







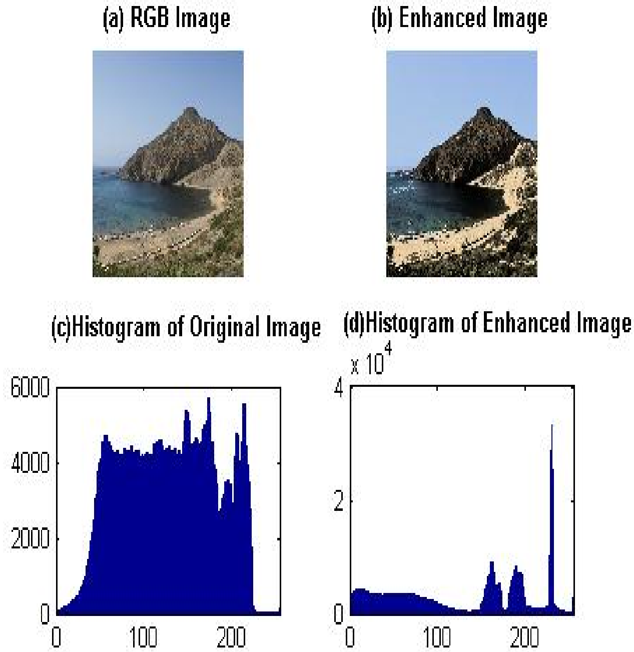


Figure 4: (a) original image, (b) enhanced image with Proposed Method (c) their Histogram of Original Image (d) Histogram of final Image

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.

TABLE I. QUANTITATIVE ENHANCEMENT ANALYSES FOR 10 STANDARD IMAGES (AVERAGE VALUES)

Image Name	PSNR	AMBE
Test Image 1	29.7867	31.5651
Test Image 2	31.3938	13.7134
Test Image 3	32.8256	21.6735
Test Image 4	32.9808	10.5681
Test Image 5	32.9351	11.9199
Test Image 6	31.9205	17.6776
Test Image 7	31.3423	7.5121
Test Image 8	33.0241	19.3208
Test Image 9	30.5073	19.1836
Test Image 10	31.0532	33.3633
Average	31.7837	18.6497

Table 1: Shows results of Peak Signal to Noise Ratio (PSNR) and Absolute Mean Brightness Error (AMBE) of proposed method with comparison to other existing methods. The comparison is done on flower image which was present in Swati Et.al. paper, For each analysis, the best results obtained are made bold.

TABLE 2. ABSOLUTE MEAN BRIGHTNESS ERROR (AMBE)

Methods	PSNR	AMBE
Using Db2	19.6085	47.1993
Using Db4	19.5806	47.4160
Using Db6	19.6944	46.6064
Swati et.al. Method	19.69	46.68
Proposed Method	30.2706	38.6727

TABLE 2: Indicates that the proposed method has the best performances in terms of smallest AMBE.

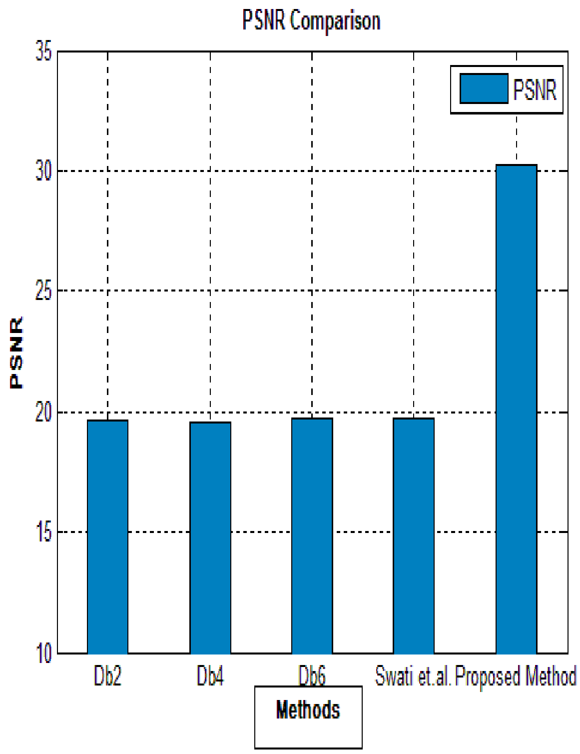


Figure 5: The PSNR comparison of our proposed Method with other existing method.

VII CONCLUSION

The main goal for image enhancement is to construct an image more suitable than the original image. Image enhancement techniques used in many areas such that Forensics, Astrophotography, Fingerprint matching etc. This paper presents a DWT based enhancement technique for low contrast color image. Proposed works transforms the RGB color image into HSI color model, then apply DWT on I component . After wavelet decomposition, histogram equalization is done just in LL frequency domain and then inverse DWT is applied. After getting the Enhanced I component, Contrast Stretching is applied on I. That will improve the intensity component globally. Besides this S component is also enhanced. Finally unmodified hue, modified Saturation and Intensity component is merged into HIS color model and HIS to RGB is applied. The proposed method gives better quality enhanced image and needs minimum processing time rather than the other methods.

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