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A novel Multiscale Image Decomposition model for Contrast Enhancement

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Abstract - An effective method to enhance the visual quality of an image is degraded by uneven light has been introduced to estimate the illumination component and compress it. Some previous techniques had the halo artifacts or contrast loss in the enhanced image due to incorrect estimation. A novel Multiscale Image Decomposition model for contrast enhancement has been proposed. The Multiscale Image Decomposition has been used for the representation of the image in the case of the weighted least square. The model purpose is to efficiently extract the reflectance and illumination layer. The illumination layer is regularized by a piecewise smoothness constraint. Then, by adjusting the illumination layer, the enhancement result has been acquired. To avoid potential color artifacts that have been introduced by the illumination of the image by adjusting and decrease computing complexity, the proposed method has been used to decompose the original image to perform on the value channel in Hue Saturation Value (HSV) space. Experiment results demonstrate that the proposed method performs enhancement process well for a wide variety of images and achieves enhanced or comparable subjective and objective quality compared with state-of-the-art methods.

Keywords -- Artifacts, Multi scale Decomposition, Complexity and Hue Saturation Value.

I. INTRODUCTION

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover, observer-specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods.

The contrast enhancement method frequently plays a crucial role in image processing. Image enhancement is the task to process an image so that the result is more suitable than the original image for specific applications. The alteration usually requires interpretation and feedback from a human evaluator of the output resulting image. Image enhancement is to improve the image quality so that the resultant image is better than the original image for a specific application or set of objectives. The channel division technique enables operation on the content of the image and therefore content such as edges and other subtle information can easily be enhanced. The process of changing the pixels' intensity of the input image, so that the output image should look better is term as image enhancement.

The purpose of image enhancement is to improve the image quality by changing pixels value such that the output image looks better than the input image. There are many image enhancement methods have been proposed. The methods which are based on the content of the image is the channel division technique. Channel division methods analyze the content of the text and boundary region and then by applying transformation function perform the enhancement [1].

A novel Multiscale Image Decomposition model for contrast enhancement has been proposed. The Multiscale Image Decomposition has been used for the representation of the image in the case of the weighted least square. The model purpose is to efficiently extract the reflectance and illumination layer.

II. REVIEW OF LITERATURE

S.S. Bedi , et al. in [2] has provided a "better transform representation for future automated image processing. One of the most important stages in medical images detection and analysis is Image Enhancement techniques which improve the quality (clarity) of images for human viewing, removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. In this paper, they present an overview of image enhancement processing techniques in the spatial domain. More specifically, they categories processing methods based on representative techniques of Image Enhancement. Thus the contribution of this paper is to classify and review image enhancement processing techniques, attempt an evaluation of shortcomings and general needs in this field of active research and in last they will point out promising directions on research for image enhancement for future research.

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Ke Gu, et al. in [3] has improved contrast without annoying artifacts. The framework combines the original image, its histogram equalized product, and its visually pleasing version created by a sigmoid transfer function that was developed in their recent work. Then, a visual quality judging criterion is developed based on the concept of saliency preservation, which assists the automatic parameters selection, and finally properly enhanced image can be generated accordingly. The author test the proposed scheme on Kodak and Video Quality Experts Group databases, and compare with the classical histogram equalization technique and its variations as well as state-of-the-art contrast enhancement approaches. The experimental results demonstrate that their technique has superior saliency preservation ability and outstanding enhancement effect.

Ke Gu, et al. in [4] has dedicated contrast-changed image database (CCID2014), this includes 655 images and associated subjective ratings recorded from 22 inexperienced observers. Then they present a novel reduced-reference image quality metric for contrast change (RIQMC) using phase congruency and statistics information of the image histogram. Validation of the proposed model is conducted on contrast related CCID2014, TID2008, CSIQ and TID2013 databases, and results justify the superiority and efficiency of RIQMC over a majority of classical and state-of-the-art IQA methods. Furthermore, they combine aforesaid subjective and objective assessments to derive the RIQMC based Optimal Histogram Mapping (ROHIM) for automatic contrast enhancement, which is shown to outperform recently developed enhancement technologies.

Sampada S Pathak , et al. in [5] has suggested a combination of local and global method for contrast image enhancement. Global contrast image enhancement improves low contrast of image in a global way. In this paper they used global contrast stretching method for global contrast image enhancement. In local contrast image enhancement method they 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.

Elena S. Yelmanova , et al. [6] has intended for the automatic preprocessing of low-contrast images with complex structure. The histogram-based method for contrast enhancement of low-contrast images with the small-size objects on the basis of the estimation of parameters of contrast distribution at boundaries of image elements for the various definitions of contrast kernels is proposed. The researches of the effectiveness for the proposed and the well-known histogram-based methods were conducted using the known no-reference contrast metrics.

Anita Thakur, et.al. in[7] has proposed a fuzzy based contrast enhancement of gray level images to investigate and establish the application of fuzzy theory for enhancing a low contrast image. Their experiment asserts that the proposed method has better performance than conventional methods. The image quality of the system has been evaluated based on visual appearance, peak signal to noise ratio and entropy. It has well established that Fuzzy logic and fuzzy sets are very good at handling many uncertainties.

Erwin, et al. in[8] has explained the three methods of image enhancement: Image Sharpening by sharpened the edges, Contrast Enhancement used Standard Histogram Equalization and Standard Median Filtering where noise has filtered using these methods first and finally noise is eliminated. Then they put on the measurement parameters using a calculation based on the image quality of the pixel MSE and PSNR and calculations based on human vision system (HVS) that SSIM. They can state that the image quality measurement is good where the results are accurate so that they can determine the best methods too. They got SSIM value is close to 1 and the value obtained MSE and PSNR is minimum in Image Sharpening which is mean Image Sharpening is best of basic methods in Image Enhancement.

Vikash Yadav, et al. [1] has proposed a comparative analysis of contrast enhancement techniques such as contrast starching, histogram equalization and Contrast-limited adaptive histogram equalization applied on different types of gray images like foggy images, sky image, photographic image, paint brush image and under water image. Experimental result shows that for foggy image Contrast-limited adaptive histogram equalization gives better result, for sky image contrast starching gives better result, for photographic image Contrast-limited adaptive histogram equalization gives better result, for under water image contrast starching gives better result, and for paint brush image Contrast-limited adaptive histogram equalization is not showing the better result. So according to above experiment Contrast-limited adaptive histogram equalization gives better image quality as compare to other above methods.

Soong-Der Chen, et al. in [9] has proposed to perform the separation based on the threshold level, which would yield minimum absolute mean brightness error (AMBE - the absolute difference between input and output mean). An efficient recursive integer-based computation for AMBE has been formulated to facilitate real time implementation. Simulation results using sample image which represent images with very low, very high and medium mean brightness show that the cases which are not handled well by Histogram equalization (HE), Bi-histogram equalization (BBHE) and dualistic sub image histogram equalization (DSIHE), can be properly enhanced by Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE). BBHE separates the input image's histogram into two based on input mean before equalizing them independently. Besides, MMBEBHE also demonstrate comparable performance with BBHE and DSIHE when come to use the sample images

Archana Singh, et al. in [10] has proposed a concept of contrast enhancement using the global mean of entire image and local mean of 3×3 sub images. Local mean filter is used to smooth the image by taking the mean value of the pixels surrounding the center pixel within the image. Experimental results based on subjective and objective evaluation have demonstrated that the proposed algorithm is able to increase the brightness of an input gray level image.

 DOI : 10.35291/2454-9150.2019.0118

Jonathan T. Barron, et al. in [11] has inferring the intrinsic, 3D structure of the world from flat, 2D images of that world fundamental problem in computer vision. Recovering these same properties from a single image seems almost impossible in comparison-there are an infinite number of shapes, paint, and lights that exactly reproduce a single image. However, certain explanations are more likely than others: surfaces tend to be smooth, paint tends to be uniform, and illumination tends to be natural. Therefore pose this problem as one of statistical inference, and define an optimization problem that searches for the most likely explanation of a single image. Here technique can be viewed as a superset of several classic computer vision problems (shape-from-shading, intrinsic images, color constancy, illumination estimation, etc) and outperforms all previous solutions to those constituent problems.

Yu Li, et al. in [12] has introduced a novel strategy that regularizes the gradients of the two layers such that one has a long tail distribution and the other a short tail distribution. While imposing the long tail distribution is a common practice, our introduction of the short tail distribution on the second layer is unique. After that formulate the problem in a probabilistic framework and describe an optimization scheme to solve this regularization with only a few iterations. Then apply their approach to the intrinsic image and reflection removal problems and demonstrate high quality layer separation on par with other techniques but being significantly faster than prevailing methods.

Umesh Kumar Sharma, et al. in [13] has focused on the comparative study of contrast enhancement techniques with special reference to HE, MHE & IDBPHE techniques. This novel method will be used in many fields, such as medical image analysis, image processing, industrial X-ray image processing, microscopic imaging etc. It has used to improve the visualization and the clarity of image or to make the original image more appropriate for computer processing. By contrast enhancement changed the intensity of pixels of an image to make it more useful for computer processing. Then study and review the different image contrast enhancement techniques because during enhancing the contrast which can losses the brightness of image. By considering this fact, the mixture of global and local contrast enhancement techniques may enhance the contrast of image with preserving its brightness.

III. EXISTING METHOD

Intrinsic image decomposition is a classical problem in computer vision and graphics. Many intelligent approaches have been proposed in literature, including single-image based, multi-image based and user-assisted based[14].

Intrinsic image decomposition is first proposed by [1], aiming to separate an image into reflectance and illumination layers. The illumination values represent the amount of reached light. The reflectance values, invariant to illumination conditions, depict the intrinsic color of the material. Since intrinsic decomposition is a highly ill-posed problem, many assumptions and priors are introduced to make this problem well-posed [15-18]. However, state-of-the-art intrinsic image decomposition models are usually designed for simple scenes consisting of objects with limited reflectance values, which may not produce good decomposition results for complex outdoor scenes.

Histogram equalization [19] is a widely used technique for contrast enhancement in a variety of applications due to its simple function and effectiveness. It works by flattening the histogram and stretching the dynamic range of the gray levels by using the cumulative density function of the image. One problem of the histogram equalization is that the brightness of an image is changed after the histogram equalization, hence not suitable for consumer electronic products, where preserving the original brightness and enhancing contrast are essential to avoid artifacts or removing the noise [20].

IV PROPOSED MULTISCALE IMAGE DECOMPOSITION METHOD

A. Introduction

The Intrinsic Decomposition method provides a Contrast Limited Adaptive Histogram Equalization (CLAHE) image enhancement technique which results in poor quality image with more time for the decomposition of image. Hence these problems have been identified and new technique of decomposition with improved image quality and reduced execution time has been provided.

AHE stands for Adaptive Histogram Equalization. It is different from ordinary histogram equalization in the sense that it is not global and it computes many histograms corresponding to different sections of an image. So, it is possible to enhance the local contrast of an image through AHE. With AHE, the information of all intensity ranges of an image can be viewed simultaneously and thereby solving the problem of many ordinary devices which are unable to depict the full dynamic intensity range. Here, first, a contextual region is defined for every pixel in the image. The contextual region is the region centered about that particular pixel.

Then, the intensity values for this region are used to find the histogram equalization mapping function. The mapping function thereby obtained is applied to the pixel being processed in the region and hence, the resultant image produced after each pixel in the image is mapping differently. These results in the local distribution of intensities and final enhancing are based on local area rather than the entire global area of the image. This is the main advantage of AHE. But, sometimes, AHE tends to over enhance the noise content that may exist in some homogeneous local block of the image by mapping a short range of pixels to a wide one.

B. Architecture of the Proposed System

The architecture of the proposed contrast enhancement method is depicted in Figure.1.

Given an input color image I, first convertthe input image into HSV representation. Second, the value (V) channel image is decomposed into illumination (L) and reflectance (R) layers using the proposed multiscale image decomposition model. That model is weighted at least square.

 DOI : 10.35291/2454-9150.2019.0118

Third, the L layer is adjusted by Gamma mapping function, producing an adjusted L layer, denoted by La. Then, adjusted La is multiplied by the reflectance layer R to generate the enhanced V channel image Ve. Since the mapping function is performed globally, the adaptive histogram equalization (AHE) adopted to further enhance the local contrast of Ve. The enhanced result is denoted as Ve1. Finally, the enhanced HSV image is transformed to RGB space, which yields the final result Ie.

C. Algorithm

The computational process of the proposed system is as follows:

Step 1: start

Step 2: Select a low contrast natural image for processing.

img = (imread(file));

Step 3: The given image is presented as histogram.

figure,imhist(rgb2gray(img));

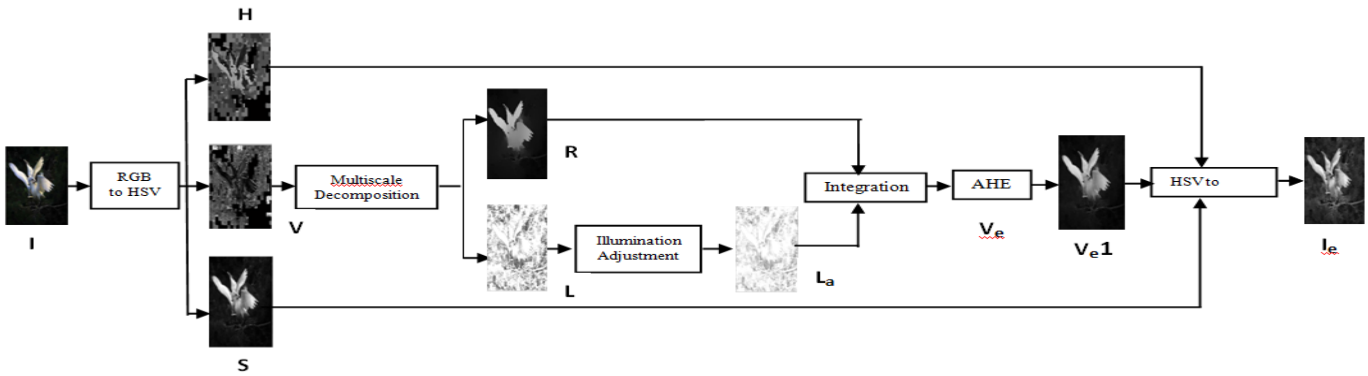

Figure 1. The architecture of the proposed system

Step 4: Convert input image of Red Green Blue (RGB) color space into Hue Saturation Value (HSV) color space.

hsv = rgb2hsv(img);

Step 5: Consider only V channel from the HSV color space.

v = hsv(:, :, 3);
I=v;

Step 6: In multiscale image decomposition process V channel image is decomposed into illumination and reflectance layers.

```
[height, width, channel] = size(I);
    M = [ ];
        for k=1:channel
            C = I(:, :, k);
M(:, :, k) = wlsFilter(C, 0.125, 4.8);
        end
```

Step 7: Using Weighted Least Square (WLS) filter first extract the base layer (reflectance layer) that is called as smoothed image.

D = I./M;

Step 8: Then estimate the detail layer (Illumination) from base layer (Reflectance).

L=(Illumination);
la=(L) .^ (1 / 2.2);

Step 9: Only illumination layer is adjusted by Gamma mapping function.

X=(reflectance).*la;

Step 10: After integrating, apply the Adaptive Histogram Equalization (AHE) method to enhance the image.

Heq = adapthisteq(X);

Step 11: Finally the enhanced HSV image is transformed to RGB space.

RGB = hsv2rgb(HSV_mod);

Step 12: As a final outcome, enhanced natural image is obtained.

imshow((RGB));

Step 13: end

D. Advantages of the Proposed Method

- Image quality is high.
- The processing time is less in image decomposition stage.

V. IMPLEMENTATION OF MULTI SCALE IMAGE DECOMPOSITION METHOD

Proposed work has six main processes.

1. Image Acquisition
2. Color conversion
3. Multiscale Image Decomposition
4. Illumination Adjustment
5. Apply AHE
6. Final Enhancement image

A. Image Acquisition

The first stage of any vision system is the image acquisition stage. The image has been obtained by dataset from Gallery.

B. Color conversion

In the proposed algorithm, a color space conversion from RGB to HSV is performed at the beginning and a reverse conversion at the end. V channel is extracted from the HSV image for further process.

C. Multiscale Image Decomposition

In the multiscale image decomposition process, V channel is decomposed into the illumination component L and Reflectance component R.

$$I = I R$$

The image decomposition process is done by using multiscale novel method. The method is weighted least squares (WLS) filter that is used for decomposing of the image in image decomposition. WLS filter first extracts the base layer that is called a smoothed image (Reflectance).

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After extract the smoothed image, estimated the detail layer (Illumination) from the base layer. Different levels of details are captured in the corresponding detail layer, with which can easily limit the amplification of unwanted details and enhance the information desirable significantly. Thus reflectance and illumination components were extracted.

D. Illumination Adjustment

After computing the reflectance and illumination layers, the following task is to adjust the illumination values to enhance image details. Log, Sigmoid and Gamma functions are used widely. It can be observed that these functions all lighten dark areas while preserving the lightness order. However, they also compress intensities in bright areas, i.e. the variation of large intensities is reduced. It will lead to the loss of details in bright areas, especially for the Log and Sigmoid functions. Therefore, the Gamma function adopts to adjust illuminations, i.e.

$$L_a = 255 \times (L/255)^{1/\gamma}$$

…….[4.1]

where γ is set to 2.2 in the experiments.

E. Apply AHE

Consequently, the adjusted illumination is multiplied by the decomposed reflectance R, generating the enhanced V channel image Ve. Further apply Adaptive Histogram Equalization (AHE) to enhanced V channel to improving the local contrast of Ve.

F. Final Enhancement Image

The enhanced result is denoted as Ve1. Then the enhanced HSV image is transformed to RGB space, generating the final result Ie.

Basic flow of Multiscale image decomposition method is given in Figure 2.

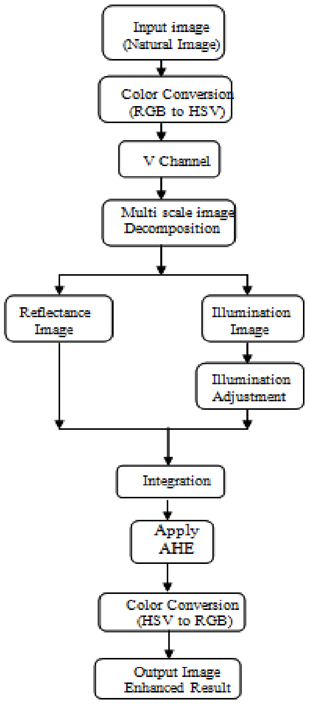

Figure 2. Flow diagram of Proposed Method

From the Figure 2, it has been represented in such a way that there are having the flow of the content and thus they are been used for the input as an image and color are been converted in such a way that there are been done using the RGB value starting from the 0-255. And the RGB value is been converted into the HSV (Hue Saturation Value), then the image is been carried out in the V channel.

Then from the channel of the V, it has been used for the multi-scale image decomposition of the image and there are been divided into the reflectance and illumination image then the illumination image is made some sort of the illumination changes. Where the integration of both the reflectance and the illumination are been merged and then by applying the AHE the image are been absolute histogram and then the finally the HSV is converted into the RGB value. And the enhancement of the image is been obtained.

V. RESULTS AND DISCUSSION

The experimental results are been done by using the MATLAB software and also the image is taken as natural scenery. And the specification used here is the R2018A is the version of the software. And also it makes the input image to obtain the enhanced in the sense of the contrast enhancement.

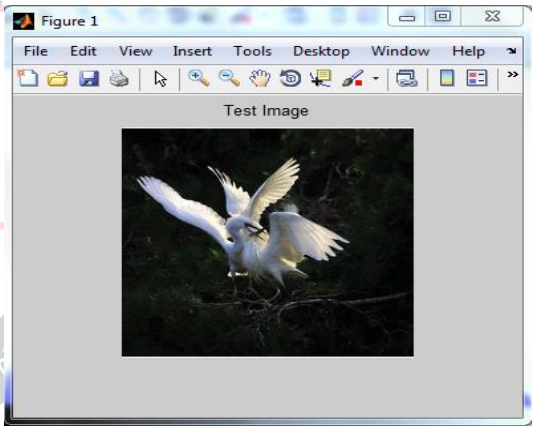

Figure 3. Test image

From the Figure 3., it is shown that the input image is the natural image of the bird and thus it is having the RGB resolution of the image. Where there are having the conversions of the RGB into the HSV based image. Thus, it is shown the initial step of the image.

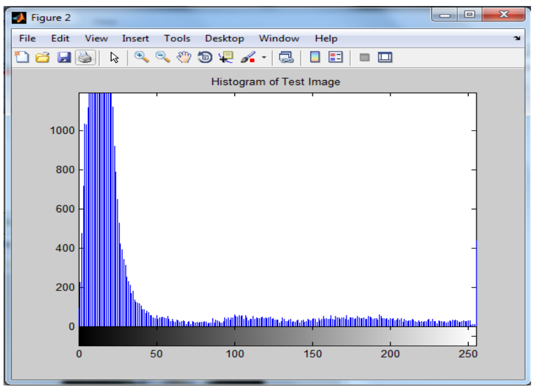

Figure 4. Histogram of the image

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From the given input image Figure 4, the histogram of the natural image is been shown in the form of the histogram. Where it ranges from the 0-255 for the color image and the intensity of the image is higher because it is the color image.

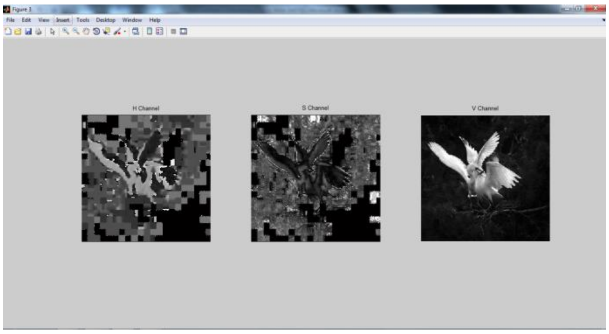

Figure 5. Applying the V Channel

In Figure 5, the given image is been applied the channel of H, from the channel H it goes to the S Channel where the image seen in the above figure is not clear to the human eyes. And the given image is been applied by the V channel. Thus, it is been shown that channel V is very clear to the color to the HSV based image.

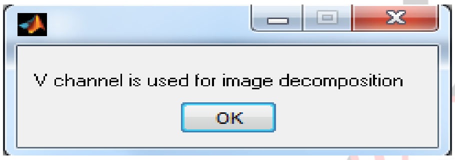

Figure 6. The display box

The display box which is shown in the above Figure 6, represents the decomposition of the image is done correctly. And thus it is been mentioned that the decomposition for the given image is applied by channel V where the image is shown in the form of the clear vision.

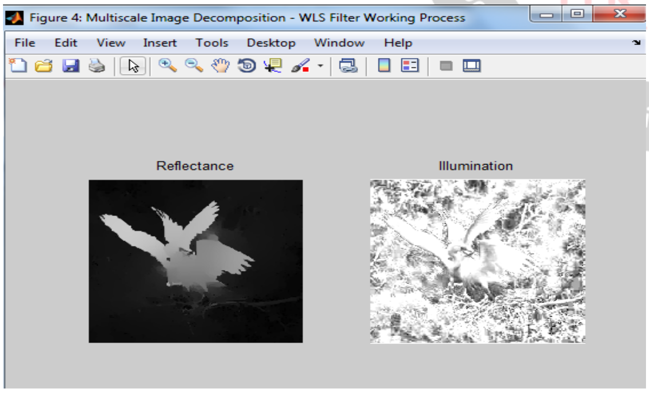

Figure 7. Reflectance and Illumination

From the above Figure 7, the image that is been from the V channel the reflectance is shown where the boundary of the image is been shown. Thus, the illumination of the reflectance of the image is been obtained in such a way that the bird's wings are seen in the image.

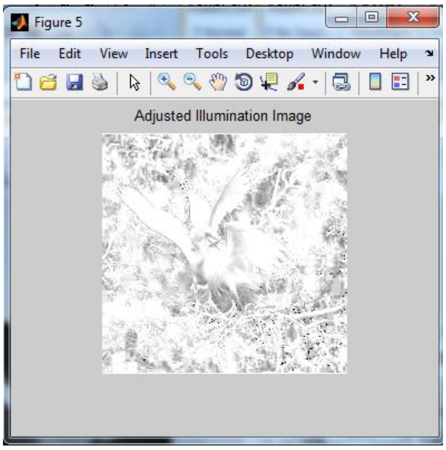

Figure 8. Illumination Adjustment

From the Figure 8, the illumination of the image is been obtained from the reflectance of the bird, and the illumination of the image is obtained from the source and by doing this there is some sort of disturbance is seen so it is necessary to adjust the illumination of image.

Figure 9. V Channel enhancement

From the Figure 9, the enhancements of the V Channel are seen in such a way that the bird images are mostly not seen in the given input image. The enhancements of the image are shown from the working of the image through the V Channel.

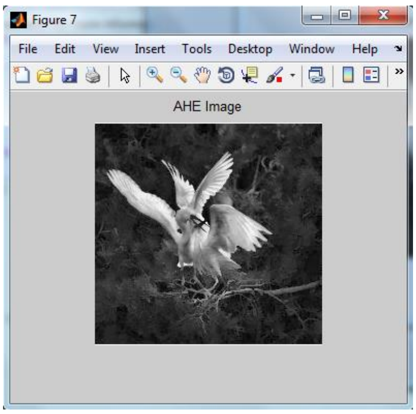

Figure 10. AHE image

The AHE of the image is been obtained in such a way that there are having the processing done on the enhanced V channel image which is been shown in Figure 10.

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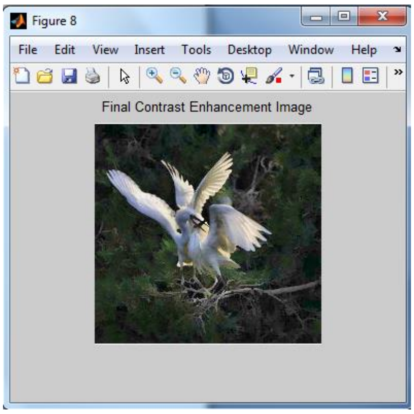


Figure 11. Contrast image

The image is been enhanced by using the AHE on the V channel image. And the final contrast enhancement of the image is been obtained from the source of the color image and it is shown in Figure 11.

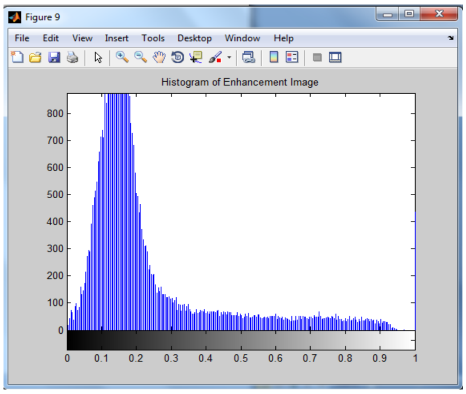
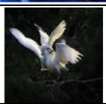
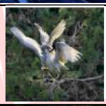
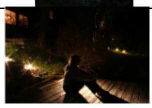
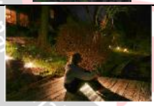
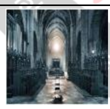


Figure 12. Enhanced histogram image

From the above image, the histogram of the enhanced image is been shown in Figure 12. By comparing the original image histogram through the resulted image histogram it is shown that the intensity is been seen in the higher range so there are efficient output is been derived.

The performance has been evaluated using metrics MSE, PSNR and Execution Time, and Enhancement performance metrics of the proposed method is depicted in the following Table 1.

Table 1 shows the performance metrics of image.

INPUT IMAGE	OUTPUT IMAGE	MSE	PSNR	EXECUTION TIME
		9.4718e+03	20.7859	9.9751
		5.2350e+03	24.8009	18.1
		2.5251e+03	35.2996	13.9538
		3.9088e+03	30.2848	11.9294
		274.0981	55.7949	10.9773

VI. CONCLUSION

The proposed framework is to enhance the images by estimating illumination and reflectance layers through a Multiscale image decomposition model. After decomposition, the image passes through the V Channel for the collection of the image into the built-in quality. It also performs Gamma correction on the illumination layer to boost the features globally. Then adopt Adaptive Histogram Equalization (AHE) method to further enhance local details on the image. The main strategy is that the original image and the output image histogram are been derived. Thus, by doing this type of calculation it passes through the H, S channel. By applying the V channel the image are obtained in the better way.

The Adaptive Histogram Equalization method has provided an image enhancement by improving contrast and good quality of image. The experimental result shows that the AHE method enhanced the quality calculated in terms of metrics with less execution time. Further research is towards reducing the execution time by using parallel processing.

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