Enhancement of Low Light Images using Adaptive Decomposition

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Abstract - The visibility and a visual quality of outdoor photos can be significantly impacted by low light. In order to remove Low Light from the acquired photographs, image de-hazing techniques are always required, which presents a hurdle in practice. Current image de-hazing algorithms prioritize improving the saturation and contrast of the entire image while ignoring the local enhancement. Both the costly depth mapping refining procedure and the priori scene depth calculation can be avoided. The texture energy, or entropy, of an image is used to calculate its energy and the quantity of information it contains. This research proposes a novel adaptive structure decomposition image fusion-based single-image de-hazing approach. Furthermore, the patch-based MEF method's Low Light images always meet the intensity decrease conditions, according to this paper.

Index Terms - Haze image, Histogram Texture Component, Adaptive Decomposition, Gaussian Filtering, Image Enhancement.

I. INTRODUCTION

The images captured in dim lighting situations as a result of inadequate lighting, The Captured image quality is completely reduced. It affects human vision and reduces the effectiveness of other operations like object recognition, video surveillance, and a few others. Many researchers have developed image enhancement methods. That are histogram-based, fusion-based, Retinex-based. The goal of fusion-based approaches is to generate high-quality images by extracting as much valuable information from each image as possible to make better brightness and contrast. The primary concept of Retinex theory is to estimate lighting component L (x, y) in order to differentiate the reflection portion R (x, y) from the original image S (x, y). Histogram-based methods use mathematical operations to change the Grey-scale range of low-light images and highlight specific areas, resulting in image enhancement. For haze images, an adaptive Gamma correction method was used in this. It is a weather occurrence caused by the absorption or reflection of radiation by atmospheric particles. As a result, removing haze is also referred to as de-hazing, and the gamma adjustment is used to extract multiple exposure images from one picture. The proposed method also includes several pre-processing steps such as RGB to grayscale conversion, Gaussian filtering, and de-hazing techniques, which helps to increase the quality of the input image. Using an adaptive decomposition technique, the aims to resolve these problems by decomposing the low-light picture into its base layer and detail layers. The primary layer contains low-frequency data and is enhanced with a de-hazing method to remove atmospheric haze and restore the image's colors and details. The detail layers reflect the high-frequency information, which is enhanced with adaptive histogram equalizing and morphological processing to improve local contrast and details This technique aims to improve low light photos overall quality and visibility, making them useful for a variety of applications. By using adaptive decomposition and a combination of enhancement techniques, it is possible to enhance low light images while maintaining their integrity and ensuring that important details are not lost.

II. METHODOLOGY

The image is first accepted as input, and then the colour image is transformed into a gray scale image because shades of Gray range from black to white. The image is analyzed using histogram. The image is processed using techniques like “Gamma Correction” and “Gaussian Filtering” to enhance its contrast and reduce noise then the image is broken into its texture components. The image dehazed to reduce any haze and finally, we get an enhanced image. We can observe the process in below.

(1) RGB to Gray Conversion

The RGB image is first converted to grayscale before the enhancement process begins. This is done to simplify the image and focus on the intensity information, which is important for the enhancement process. A weighted average of the RGB colour channels is found for each pixel when converting to grayscale. This conversion's method is:

Greyscale = (r + g + b) / 3
Greyscale = r/3 + g/3 + b/3
Greyscale = 0.297 * r + 0.588 * g + 0.114 * b
Where r, g, and b are red, green, and blue values for a particular pixel, and Gray is the resulting grayscale value.
Green light is more damaging to the human vision compared to red or blue light in this case. As a result, the green channel is given more weight than the other two.

(2) Histogram

The histogram is a plot of the image's pixel intensity range that gives information about the image's contrast and brightness. By analysing the histogram of the grayscale image, we can identify areas of low contrast or low light, which need to be enhanced. Specifically, we look for peaks and valleys in the histogram that correspond to areas of the image that are overexposed (too bright) or underexposed (too dark). The histogram of an image with N pixels and K intensity levels given as:

$$h(i) = n(i) / N$$

Where, h(i) is the value of histogram at intensity level (i), n(i) is the number of pixels in an image with intensity level “i” and N is the total amount of pixels in an image.

(3) Gamma Correction

The Gamma correction is the process of changing the light intensity of a picture to make it appear brighter or darker. The gamma function is a mathematical function that converts brightness numbers from input to outcome. The gamma function is described as follows:

$$O = ((I/255)^{\wedge}I/).255$$

Where I denote the initial brightness, O is the final brightness value, and gamma is the gamma correction strength parameter.

(4) Gaussian Filtering

An image is smoothed using the Gaussian filtering process, which convolves the image with a Gaussian function. Using the bell shaped gaussian function the probability distribution is represented. The equation for the Gaussian function is:

$$G (x, y) = (1/(2\pi\sigma^2)) * e (-(x^2 + y^2)/(2\sigma^2))$$

where G (x, y) is the Gaussian function at position (x, y), σ is the standard deviation of the distribution, and e is the exponential function.

(5) Texture Components

The fine details in an image that are linked to its texture, such as patterns, edges, and roughness, are referred to as texture components. These texture components are frequently difficult to see in low-light pictures due to noise and other imperfections.

$$T (x, y) =I (x, y)-S (x, y)$$

Where T (x, y) represents the texture component at a pixel (x, y), I (x, y) represent the luminance value of the input image at a pixel (x, y), and S (x, y) represents the smoothed version of the input image at a pixel (x, y).

(6) Adaptive Decomposition

The Adaptive decomposition is a technique used to decompose an image into different frequency bands, with each band representing a different level of detail. There are several methods for adaptive decomposition, such as the wavelet transform and the Laplacian pyramid. After decomposing the image frequency bands, the texture components can be extracted by choosing the high-frequency bands. These high-frequency bands are then enhanced using various image processing techniques, such as contrast-enhancement, histogram equalization, or dehazing.

$$I (x, y) = T (x, y) + L (x, y)$$

Where I (x, y) is the input image, T (x, y) is the texture component, and L (x, y) is the low frequency component.

(7) Dehazed Image

Dehazing is a process of removing the haze or atmospheric scattering from images that are captured in outdoor or indoor environments with poor lighting conditions. Little atmospheric particles like dust, smoke, or water droplets and absorb light, creating haze or fog. This reduces the contrast and clarity in the scene.

$$J(x) = I(x) t(x) + L (1 - t(x))$$

Where, I(x) is the observed image at pixel location x, J(x) is the scene radiance at pixel location x, t(x) is the transmission map at pixel location x, L is the atmospheric light, and (1 - t(x)) is the haze component.

(8) Performance Parameters

Resolution: Resolution is the number of pixels in an image, which determines the level of detail and sharpness of the image.
Resolution = Number of Pixels / Image Size

Mean: Mean is a measure of the central tendency that represents the average value of the pixel intensities in an image.
Mean = (1/N) * ∑i = 1: N (xi)

Here, "N" is the number of pixels in the image and "xi" is the pixel intensity value at position i.
Standard Deviation: It is a measure of the spread or dispersion of the pixel intensity values in an image.
Standard Deviation = sqrt((1/N) * ∑i = 1: N (xi - mean) ^2)

Entropy: It is a measure of the amount of information in an image. It represents the average amount of uncertainty or randomness in the pixel intensity values.
Entropy = -∑i = 0: L-1 p(i) * log2(p(i))
Here, "L" is the amount of intensity levels and "p(i)" is the probability of occurrence.

RMS**:** RMS (Root Mean Square) is a measure of the pixel intensity values in an image. It indicates the amount of energy or power contained in the image.
RMS = sqrt((1/N) * ∑i = 1: N(xi)^2)

III. BLOCK DIAGRAM

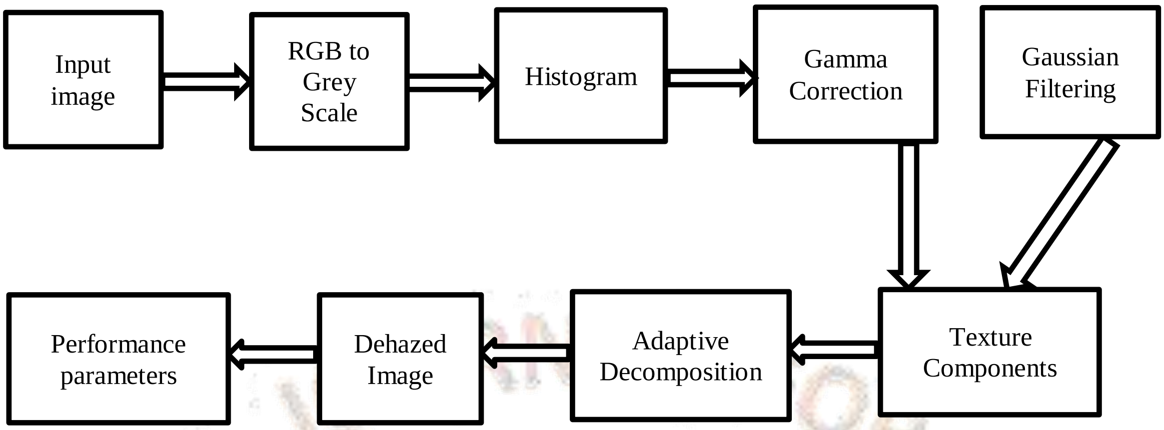

Fig 1 Block Diagram

IV. RESULTS

The method aims to improve the quality of low-light images by removing haze, increasing contrast and sharpness, and reducing noise. It achieves this by using a combination of techniques including gamma correction, Gaussian filtering, and adaptive decomposition. The input image is first converted to grayscale, and its histogram is equalized to improve contrast. Then, the gamma-corrected image is obtained to enhance the overall brightness. A Gaussian filter is applied to remove noise and blur the image. Next, the image is decomposed into its base and detail layers, with the detail layer further divided into the texture and edge components. The texture component is enhanced using adaptive decomposition, which effectively separates the texture features from the image and enhances them to improve texture clarity. The illumination and enhanced texture components are combined to produce the dehazed output image. The method is evaluated based on Resolution, Mean, Standard Deviation, Entropy, RMS, Variance and the results show significant improvements in the image quality.

PARAMETERS	RESULT
Resolution	519 x768
Mean	0.4902
Standard Deviation	0.2469
Entropy	7.2340
RMS	0.5466
Variance	0.0586

Table1 Performance Parameter

The Dehazed image quality shows how different methods for evaluating hazy images generate different outcomes. Image dehazing is balanced for both the background and foreground regions of an image. This indicates that visibility enhances in both close-up and distant objects. Finally, the enhanced texture component is added back to the other components, and the image is recombined to produce the final output. The algorithm also includes parameters such as clipping range, which controls the dynamic range of the image, and processing time, which determines the speed of the algorithm. Overall, the algorithm improves the resolution, contrast, and accuracy of low-light images while reducing noise and enhancing edges.
The original image which is taken as a input image is shown in the figure 1.1

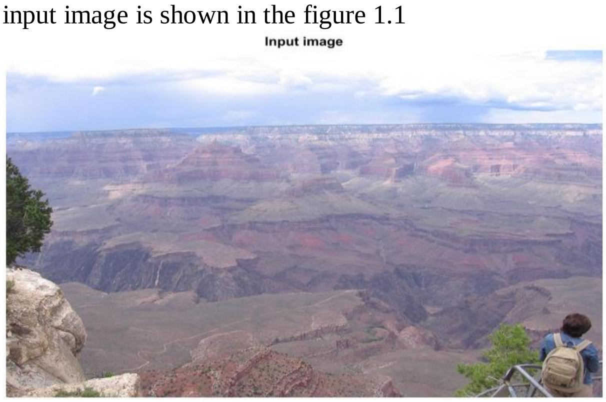

Fig 1.1 Original Image

The RGB to Grey Scale image is converted from the original image which is shown in the figure 1.2

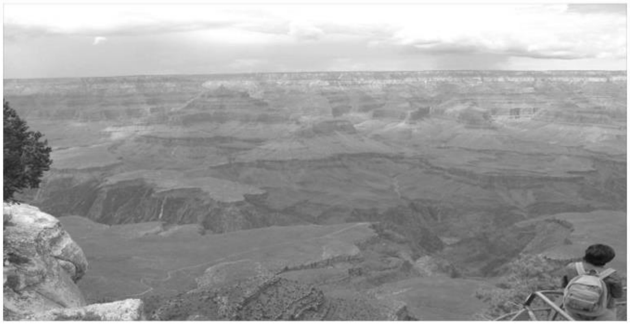

Fig 1.2 Grey Scale Image

Histogram of Grey Scale Image is shown in the figure 1.3

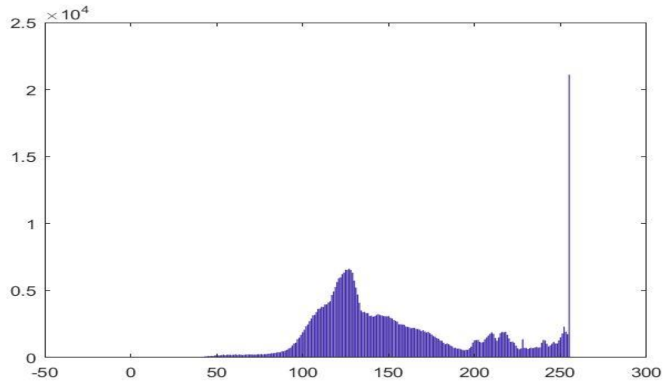

Fig 1.3 Histogram of Greyscale Image

After conversion, the image gets smoother by applying Gaussian filter is shown in the figure 1.4

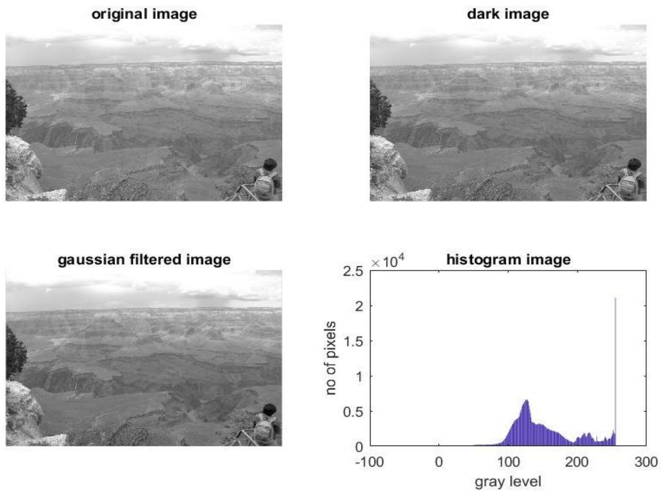

Fig 1.4 Gaussian Filtering

Here, the image is broken into its texture components, which helps to identify the fine details in an image is shown in the figure 1.5

Fig 1.5 Texture Component

The removal of haze image is shown in the figure 1.6

Fig 1.6 Dehazed Image

Finally, we can observe the output image which is shown in the figure 1.7

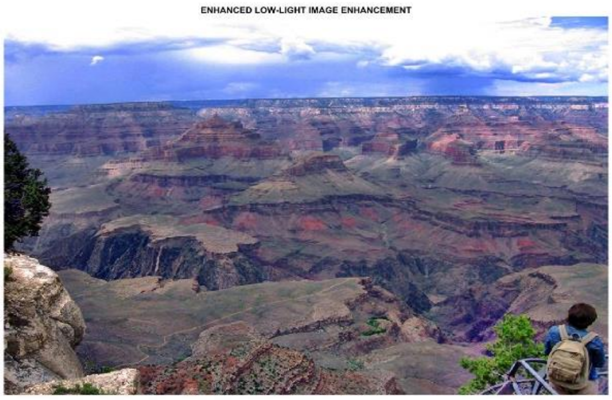

Fig 1.7 Enhanced Image

V. CONCLUSION

The adaptive decomposition method is used to divide the input picture into base and detail layers, which are then enhanced independently using adaptive histogram equalization and morphological operations. The reducing hazing technique is used to estimate the transmission map and remove climatic haze from the input image, resulting in a dehazed image with restored colors and details. Based on results, the method enhances the clarity of pictures with poor lighting and outperforms several current techniques in terms of objective and subjective evaluation metrics. The method is also computationally efficient, and it can be applied with poor lighting captured in a diversity of conditions. Finally, the paper "Enhancement of images with low light using adaptive decomposition" provides a promising method for improving low-light image quality by combining adaptive decomposition and dehazing techniques. The proposed method can be useful in various applications such as surveillance, astronomy, medical imaging, and more.

VI. REFERENCES

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