SINGLE IMAGE CONTRAST ENHANCER BASED ON PROPOSED MEDIAN EQUALIZED STRETCHED RETINEX (MESR) METHOD

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Abstract: **limitation in modern digital cameras in capturing high dynamic range images in which image contrast enhancement situation always needed at the processing device also Noise in image frames creates the serious poverty of image quality. The noise remains as large residual errors after motion compensation. The typical digital cameras can only capture images with a dynamic range of thousands in magnitude just because of that limited dynamic range of digital cameras, poor visibility causes due to overexposure in bright regions and underexposure in dark regions of a captured image. If the intensity of noise is higher than the signal then the conventional de-noising techniques cannot work properly. This paper is elaborating a method for image adaptive contrast enhancement which is better than different types of method and technologies of image enhancement on parameters of SNR, LOE and entropy. Proposed method is named as median equalized stretched retinex (MESR) method where three different methods of image contrast enhancement are in use with a specific sequencing.**

Keywords: **Contrast Enhancement, multi-scale Intensity retinex, quality assessment, Lightness Order Error**

I-INTRODUCTION

Various image enhancement techniques are thus highly needed to recover image details or lift image aesthetics. For example, the rich user-generated contents from social media can be fully adopted to optimize the scene composition [2] [3]. In these learning based methods, novel pattern analysis models [4] [5] are necessary to capture the semantics from visually similar exemplars. Aiming at changing a photograph at the content level, the learning based methods are usually computationally expensive. Furthermore, for processing an arbitrarily new photograph, sufficient training exemplars are needed at the server side. We argue that there is no need to process every image in visual big data at the cloud server side. For example, to deal with challenging imaging conditions, the image manipulation has to be on the pixel-wise level, where efficient filtering at the side of each mobile device can be more feasible. Due to insufficient lighting conditions, low illumination color images are often appears and not only brings an uncomfortable visual feeling to human, but also is not beneficial for image analysis and comprehension and so on, they need to be enhanced to improve visual effect of such images.

The enhance algorithm based on fixed Histogram was used by [3] and [5] which works well for certain images only, and also the gray level of the processed image by [3] and [5] is reduced, so that some details are partially lost. Due to its multi-resolution characteristics, the enhancement algorithm based on wavelet transform [1], [2] and [4] both can describe the outline of the image, but also can highlight the details of the image, but there is no great effect on changing the contrast of the image, and the multilevel wavelet decomposition will increase the computational complexity and reduce the efficiency of the algorithm. Proposed work is using Adaptive Histogram equalization, which improves the contrast of the any image, with significant light enhancement process like Interpolation and Retinex.

II-PROPOSED METHODOLOGY

Proposed an algorithm which combines the merits of transform color space algorithm and wavelet transform algorithm. First, the RGB image is converted to the HSI color space,

Then Adaptive Histogram equalization is applied to intensity component I to enhance the contrast of image and the segmentation, Exponential enhancement algorithm is applied to saturation component S, and then the intensity component I is divided into high and low frequency sub-bands with wavelet transform. And then Intensity retinex algorithm is applied to the low-frequency sub-band to reduce the effect of contrast and adjust image luminance.

A Newton Raphson regression based image interpolation applied on the high frequency region of the image which first enhance the pixels which highlights the edges and rapid changes then the Retinex applied on this region. It has to be done for preserving the edges and naturalness of the image with light enhancement. after enhancement in interpolated high frequency region, the high frequency sub-and again decimate to its original size.

Finally, utilize the inverse wavelet transform to reconstruct the I component and then the reconstructed component I will be synthesized with H and S components to get a clear RGB image, and the proposed algorithm is represented by following flowchart

Step 1: Input image for the any location in computer as the test image which we want to enhance the color.

Step 2: apply median filter on the image for removal of noise elements like salt and paper noise and any other noises.

Step 3: Isolate Red, Green and blue frames for individual equalization of image frame which removes hazing effect

Step 4: perform Adaptive Histogram Equalization on image frames separately for equalizing the color amount in the image

Step 5: after equalization now merge the individual red, green and blue frame and perform RGB stretching on the image which increase the overall color brightness

Step 6: now converts the RGB format of image to HSI format , HSI format provide intensity information of the image along with its color, and as proposed work is all about light enhancement then the process must use HSI.
Step 7: now applies DWT on the intensity part of the image, for isolating lower and higher frequency parts of image, lower part can be process directly as it does not have big variation but the higher part of the image having high variation which cannot easily enhance. hence required to apply different enhancement methods for lower and higher part of image.
Step 8: Apply Intensity retinex intensity enhancement method on the Lower frequency part of the intensity frame of image.

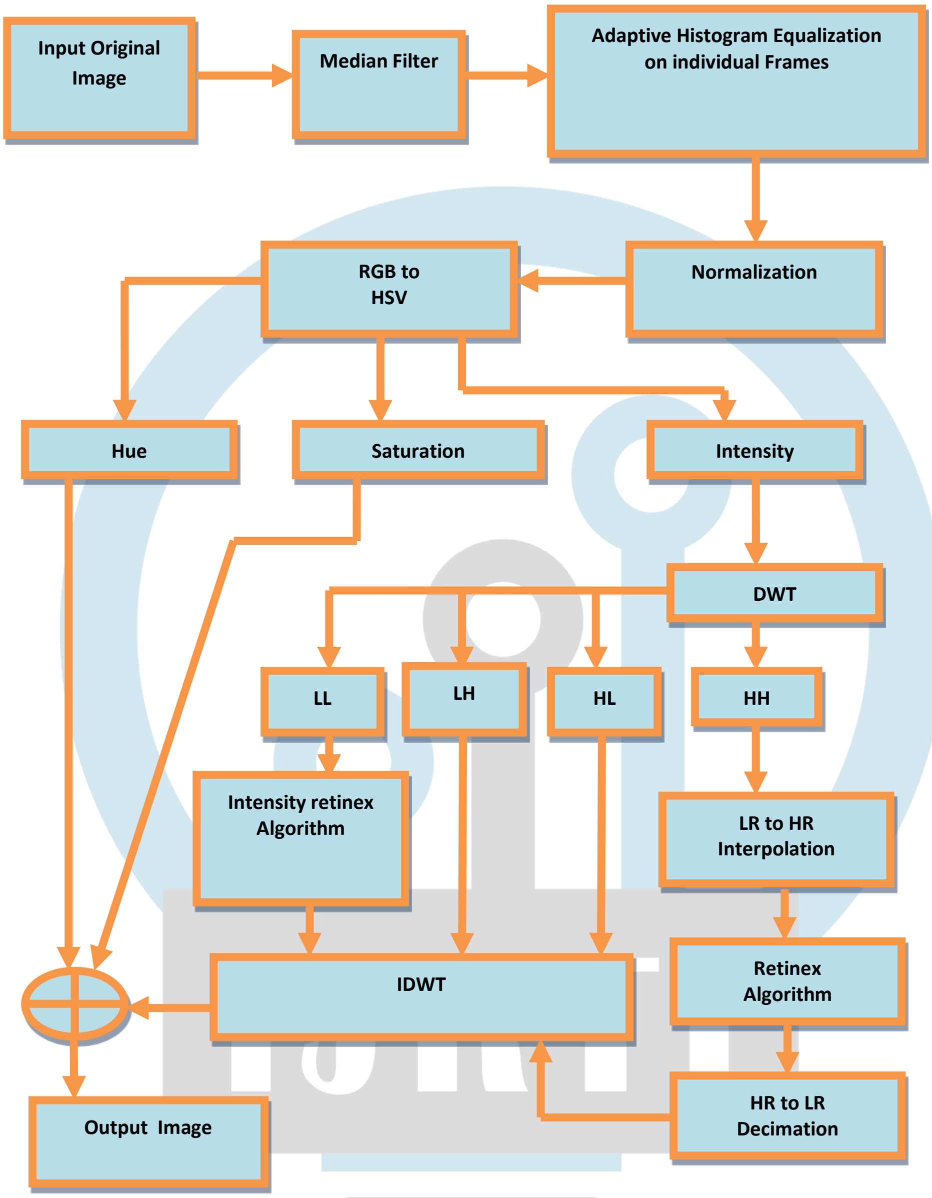

Figure 1 Flow diagram of proposed work

Step 9: apply proposed newton raphson interpolation on the high frequency part of intensity frame of image, which first increase the pixels and then enhance the pixel value with a Thresholding and then again reduce the pixel at its original size.
Step 10: perform Inverse DWT on the modifies high and low frequency parts of image.
Step 11: now merge Hue, saturation and modified intensity frames of the image.

III-ALGORITHM ADOPTED

Step 1: Apply Median Filter The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction[4] is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. For 1D signals, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible (such as "box" or "cross" patterns).

$$\boldsymbol{Nimg_{ij}} = \sum_{i,j=k}^{k+3} \boldsymbol{img_{ij}} \Big/ \boldsymbol{9} \quad ......(1)$$

here i and j represents space position of pixel intensity and 'img' is image

Step 2: Adaptive Histogram Equalization-Equalization is a method in image processing of contrast adjustment using the image's Adaptive Histogram, This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the Adaptive Histogram. This allows for areas of lower local contrast to gain a higher contrast[1]. Adaptive Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in ray images, and to better detail in photographs that are over or under-exposed. Adaptive Histogram equalization often produces unrealistic effects in photographs; however it is very useful for scientific images like thermal, satellite or x-ray images, often the same class of images to which one would apply false-color. Also Adaptive Histogram equalization can produce undesirable effects (like visible image) when applied to images with low color depth. For example, if applied to 8-bit image displayed with 8-bit gray-scale palette it will further reduce color depth (number of unique shades of gray) of the image.

Let 'img' is the RGB image and its intensity block is of 3x3 is as below, and the intensity need to enhance with K coefficient, and let I is any one frame out of R, G or B

$$I = \begin{bmatrix} A & B & A \\ C & D & B \\ D & B & E \end{bmatrix} \quad ....(2)$$

A, B, C are the pixel value in original image before equalization

Table 1 Adaptive equalization algorithm

Pixel intensity	A	B	C	D	E
Pixel value	F1	F2	F3	F4	F5
Probability	F1/9	F2/9	F3/9	F4/9	F5/9
Cumulative probability	F1/9	$\frac{F1+F2}{9}$	$\frac{F1+F2+F3}{9}$	$\frac{F1+F2+F3+F4}{9}$	$\frac{F1+F2+F3+F4+F5}{9}$
CP*k	K*F1/9	$\left\{\frac{F1+F2}{9}\right\} * K$	$\left\{\frac{F1+F2+F3}{9}\right\} * K$	$\left\{\frac{F1+F2+F3+F4}{9}\right\} * K$	$\left\{\frac{F1+F2+F3+F4+F5}{9}\right\} * K$
Floor rounding	Ma= FLOOR(K*F1/9)	$Mb = floor\left[\left\{\frac{F1+F2}{9}\right\} * K\right]$		$Mc = floor\left[\left\{\frac{F1+F2+F3}{9}\right\} * K\right]$	
	$Md = floor\left[\left\{\frac{F1+F2+F3+F4}{9}\right\} * K\right]$			$Me = floor\left[\left\{\frac{F1+F2+F3+F4+F5}{9}\right\} * K\right]$	

$$I_e = \begin{bmatrix} Ma & Mb & Ma \\ Mc & Md & Mb \\ Md & Mb & Me \end{bmatrix} \quad ....(3)$$

I_e is the new Equalized frame of RGB image where Ma, Mb, Mc are the pixel value in Equalize image

Step 3: RGB 2 HSI conversion- The HSI color space is very important and attractive color model for image processing applications because it represents color s similarly how the human eye senses colors. The HSI color model represents every color with three components: hue (H), saturation (S), intensity (I). The below figure illustrates how the HIS color space represents colors

Let input image is x which is a RGB image

$$I = \frac{1}{3}(R + G + B) \quad .....(4)$$

$$A = cos^{-1}\left(\frac{(R-G)+(R-B)}{2\sqrt{(R-G)^2 + (R-B)(G-B)}}\right) \quad .....(5)$$

$$H = A \quad when\ G > B ....(6)$$

$$H = 360 - A \quad when\ B > G \quad ...(7)$$

$$S = 1 - 3\left(\frac{Min(R,G,B)}{I}\right) ....(8)$$

Step 4: DWT of I part of HSI image- In numerical analysis and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. Wavelets are often used to de-noise two dimensional signals, such as images.

$$I_e(\boldsymbol{n})_L = \sum_{k=-\infty}^{\infty} I_e(\boldsymbol{k})\boldsymbol{g}(\boldsymbol{2n-k}) \quad .....(9)$$

$$I_e(\boldsymbol{n})_H = \sum_{k=-\infty}^{\infty} I_e(\boldsymbol{k})\boldsymbol{h}(\boldsymbol{2n-k}) \quad .....(10)$$

let $I_e(\boldsymbol{n})_L = p$

let $I_e(\boldsymbol{n})_H = q$

$I_e(\boldsymbol{n})_L$ is the low Pixel frequency, $I_e(\boldsymbol{n})_H$ is the high pixel frequency, n is total pixels, k is current pixel of processing.

Step 5: Intensity retinex- Intensity retinex image enhancement technique is an attempt to model human vision system. Scope of this nonlinear enhancement algorithm is immense which makes it a powerful algorithm. The most important application of Intensity

retinex algorithm is the development of visibility improvement system for helping drivers with poor vision at night and bad weather condition. Proposed work applying Intensity retinex on Lower Frequency Elements.
let (x,y) are the pixels coordinates of 'p' in space domain then W is the reflection component and Z illumination component then

$$\mathrm{p(x,y) = W(x,y)Z(x,y)} \text{ ...(11)}$$
$$where\ Z(x,y) = \sum_{r=-\infty}^{\infty}\sum_{s=-\infty}^{\infty} F(r,s).p(x-r,y-s) \text{...(12)}$$
$$F(x,y) = \lambda.e^{\frac{-(x^2+y^2)}{c}} \text{...(13)}$$
Where c is Gaussian scale is a constant that makes F(x, y) equal to 1. λ ratinex factor.
$$\mathrm{p(x,y) = W(x,y)\{F(x,y) * p(x,y)\}} \text{ ...(14)}$$
$$w(x,y) = log_{10}(W(x,y)) = log_{10}(p(x,y)) - log_{10}(F(x,y) * p(x,y)) \text{...(15)}$$
$$w(x,y)\ will\ be\ the\ ratinex\ enhance\ of\ p(x,y) \text{...(16)}$$

let (u,v) are the pixels coordinates of 'q' in space domain
Step 6 Interpolation Method-Image interpolation occurs in all digital photos at some stage whether this be in bayer demosaicing or in photo enlargement. It happens anytime you resize or remap (distort) your image from one pixel grid to another. Image resizing is necessary when you need to increase or decrease the total number of pixels, whereas remapping can occur under a wider variety of scenarios: correcting for lens distortion, changing perspective, and rotating an image.
Proposed work use interpolation on higher frequency elements of HSI image and then simple contrast enhancement and again decimate it to original size.

$$F_{(u,v)} = \frac{q_{(u,v)} - q_{min}}{q_{max} - q_{min}} \text{....(17)}$$
$$NF_{(u,v)} = \frac{1}{2} + \left(F_{(u,v)} - \frac{1}{2}\right)^{\frac{1}{3}} \text{...(18)}$$
$$MF_{(u,v)} = NF_{(u,v)}(q_{max} - q_{min}) + q_{min} \text{...(19)}$$
$$Mq = MF_{(u,v)} * q_{(u,v)} \text{...(20)}$$
Mq is the final enhanced high frequency component q
$$\mathrm{Mod\_I} = \sum_{n=-\infty}^{\infty}\left\{Mq\left(\frac{n}{2}\right)_L \pm W\left(\frac{n}{2}\right)_H\right\} \text{...(21)}$$
Step 7: inverse DWT- after all enhancement in high and low frequency we will perform IDWT
newI= IDWT(newHH, HL, LH, newLL) ...(22)
Step 8: now merge H, S and Modified I part so we can get final light enhanced HSI image
final image= Cat(H, S, Modified-I) ...(23)

IV-RESULTS

If U is original image, luminance or lightness L of an image X is the maximum of its three color channel.
$$L = MAX_{(r,g,b)}(X_{ij}) \text{...(24)}$$
i and j are the space position of pixel.
RD_{ij} is the relative order difference can be computed as
$$RD_{ij} = \sum_{i=1}^{RW}\sum_{j=1}^{CL}\left(U\left(L_x, L_{ij_x}\right) \oplus U(L_y, L_{ij_y})\right) \text{..(25)}$$
LOE measure is based on the lightness order error between original image X and enhanced image Y .The LOE measure is defined as
$$LOE = \sum_{i=1}^{RW}\sum_{j=1}^{CL} RD_{ij} \text{..(26)}$$
where RW is total number of Rows in image and CL is total number of column in image.

Simulation is been taken for test images 'Babyatwin'

Figure 2 Orignal test image

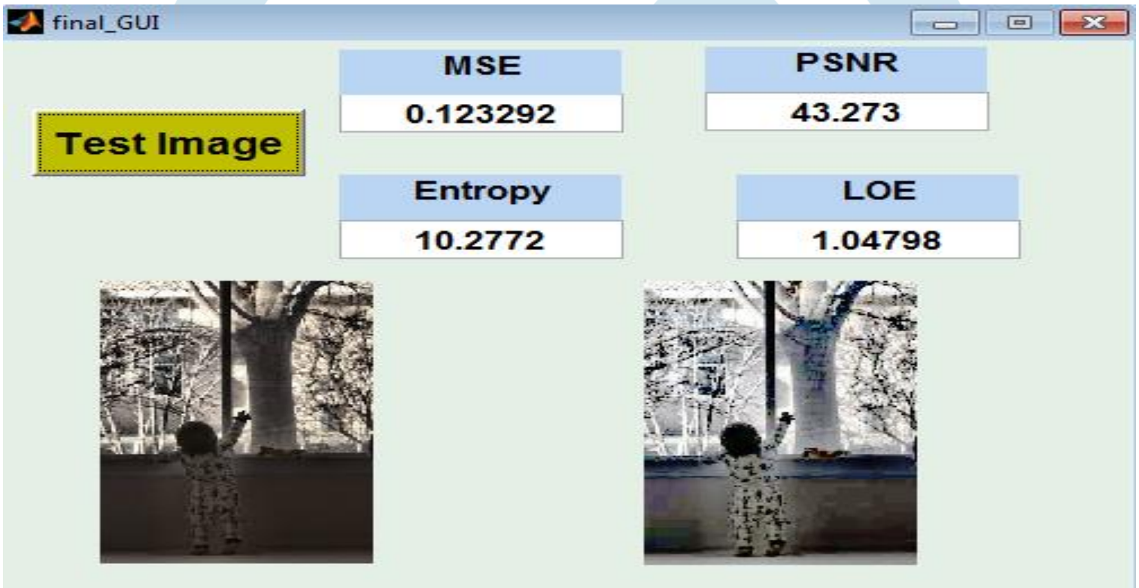

Figure 3 GUI for the test image Babyatwin

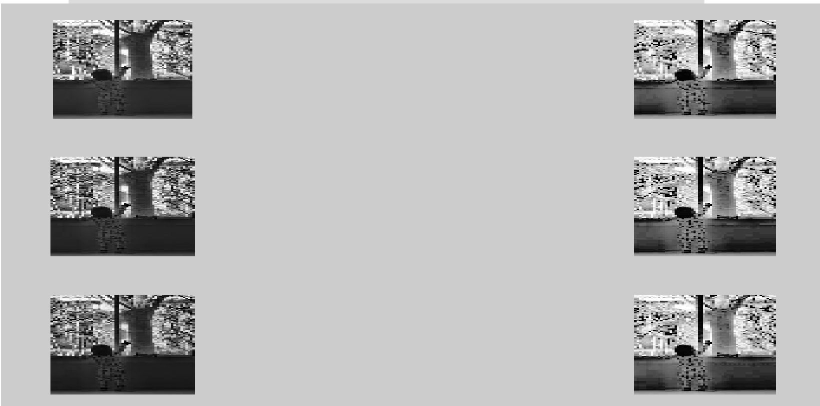

Figure 4 test image 'Babyatwin' RGB to HSI with light enhancement

Figure 5 Enhanced test image 'Babyatwin'

Tables below shows the observe results of the proposed simulation for test images Babyatwin.

Table 2 observe results of PSNR, Entropy and Light of Error

SN	Test Image	PSNR	Entropy	LOE
1	Babyatwin	43.273	10.2772	1.04798

Observe PSNR is 43.27 in output image is higher than input image PSNR of 35.51.

Table 3 Light of Error results comparison between Xiaojie Guo [1] and proposed work when implemented in MATLAB

Test Image	LOE obtain by Xiaojie Guo	LOE in Proposed work	Percentage change
Babyatwin	3.263	1.04798	67.5% less is proposed work

we can also compare difference between their work by Fan wu[2] implementation and proposed work implementation and it can be observe that proposed work has better in all parameter for all test images.

Table 4 LOE and Entropy comparison between Fan wu [2]] and proposed work when implemented in MATLAB

Parameter	Fan wu [2]	Proposed work	Percentage change
Entropy	7.87	9.9651	26% more in proposed work
LOE	3.7584	8.3527	76% more in proposed work

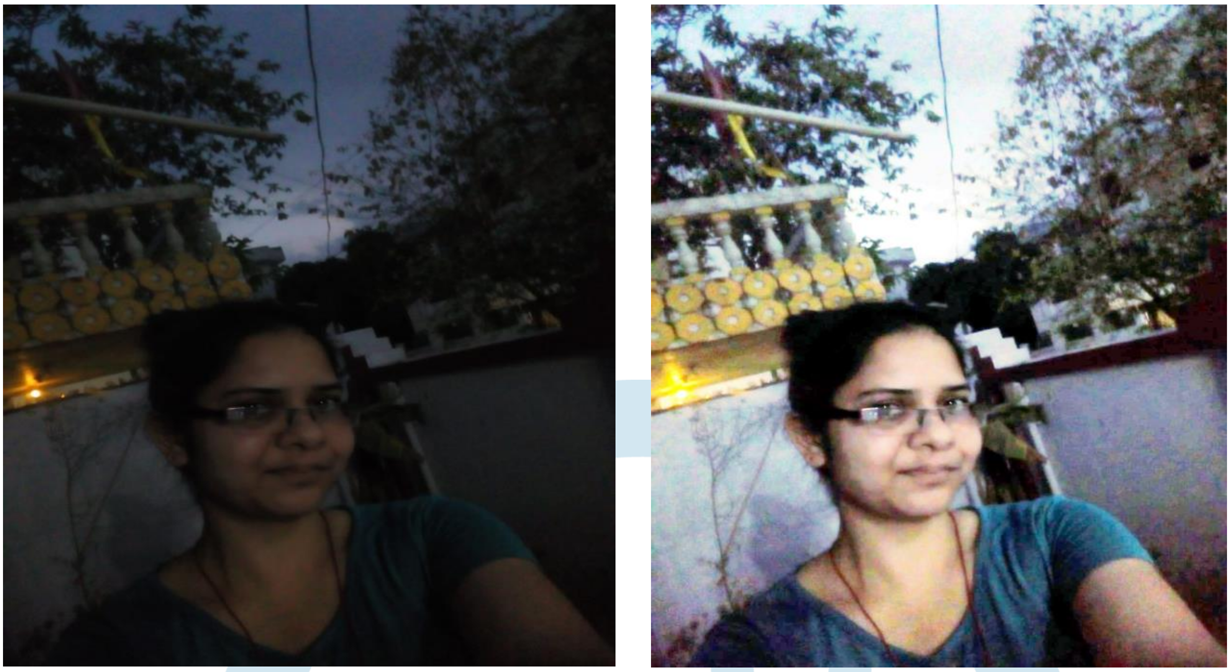

Figure 6 Real image before and after enhancement

V-CONCLUSION

This paper presents a survey of different types of methods and technologies that have been used for image enhancement. But the low contrast and noise remains a barrier to visually pleasing images in contrast conditions. In that condition, to find out a more accuracy in image enhancement process there is need to detect and measure the intensity level of individual pixel channel as well as have to present an appropriate enhancement factor for enhancement purpose, so that effective and efficient image enhancement process will be created. A low-light image enhancement algorithm is presented in the paper. By decomposing a low-light image into the Red, green and blue component and performing Adaptive Histogram equalization in all R,G and B components color stretching is been performed. Further illumination component extracted, it offers a solution to expand illumination and enhances image details separately. Specifically, the illumination component is processed using DWT, intensity retinex and interpolation methods. This solution enhances low-light images and effectively avoids distortions (for example color) and annoying artefacts (e.g., blurring, halo). Then, the final result is obtained by concatenation of illumination component with hue and saturation. Experimental results demonstrate that the enhanced images by the proposed method are visually pleasing by subjective test and the performance of the proposed method outperforms the existing methods in terms of both , , MSE, LOE, SNR and entropy. Moreover, the proposed algorithm is efficient because the computation complexity is less then [1]. The proposed method has great potential to implement in real-time low-light image processing.

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