© 2018 IJRTI | Volume 3, Issue 10 | ISSN: 2456-3315

IMAGE LOW LIGHT AND QUALITY ENHANCEMENT WITH MODIFIED EQUALIZATION STRETCHING RETINEX AND INTERPOLATION (MESRI)

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Abstract: **From last few years, there has been substantial work on image processing and wide improvements being carried out in image processing including resolutions and sensitivity. Despite these improvements, still there is a problem to capture a high dynamic range images in low-light conditions especially when light is very low. If the intensity of noise is higher than the signal then the conventional de-noising techniques cannot work properly. For the said problem there are many approaches being developed for low-light image enhancement but still Low contrast and noise remains a barrier to visually pleasing images in low light conditions. To capturing images in concerts, parties, social gatherings, and in security monitoring situations are still an unanswered problem. In such conditions the image enhancement of low quality image is a really tedious job. This new algorithm enhances the luminance of low-light level images while preserving image contrast and details. The study is further going on to find a technique so that more accuracy can obtained in image enhancement.**

Keywords: **QA: quality assessment, LLI: low light images, LIME: Low-light Image Enhancement via Illumination Map Estimation, LOE: Lightness Order Error**

I-INTRODUCTION

Over the previous couple of years, there has been a in depth capability improvement were take place in digital cameras within the space of resolutions and sensitivity But still there is limitation in modern digital cameras in capturing high dynamic range images in low-light situation [1]. Noise in image frames creates the serious poverty of image quality [3]. The noise remains as large residual errors after motion compensation [3]. 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 [4]. During processing of very dark images mostly specific algorithms being adopted for enhancement process which causes of low dynamic range images remains largely untouched [5]. It is always expected that the digital camera should work effectively in all types of lighting and weather conditions but the majority of these cameras are failed to capture images in low light state, hence the low quality of images and being captured [6]. The prime intention of image enhancement is to bring out detail information that is hidden in image [7].Imageup gradation or enhancement may be defined as to give an input of low light or low quality image and collect the high quality image output for specific applications. Images are the integral part of our life and that's why it's an active subject which brings much attention in recent years [10]. Color of the objects with similar background, low intensity of light (low light condition) and the unknown level of darkness while capturing an image, make it more complicated [10]. This investigation is going to present a survey of different types of methods and technologies that have been used for image enhancement and will help to design and develop a technology which will deliver more accuracy in image enhancement.

II-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 histogram equalization is applied to intensity component ,saturation component and hue component individually to enhance the contrast of image and then the intensity component I is divided into high and low frequency sub-bands with wavelet transform and then Retinex algorithm is applied to the low-frequency sub-band to reduce the effect of light and adjust image luminance, an interpolation filter is applied to high-frequency sub-band to achieve the enhancement and de-noising for the image details. Finally, we use 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

ALGORITHM ADOPTED: Let input image is x which is a RGB image

First Histogram Equalization need to be done

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

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

$$H = AwhenG > B$$

$$H = 360 - AwhenB > G$$

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

Let ‘img’ is the HSI image and its intensity block is of 3x3 is as below, and the intensity need to enhance with K coefficient

$$I = \begin{bmatrix} a & b & a \\ c & d & b \\ d & b & e \end{bmatrix}$$

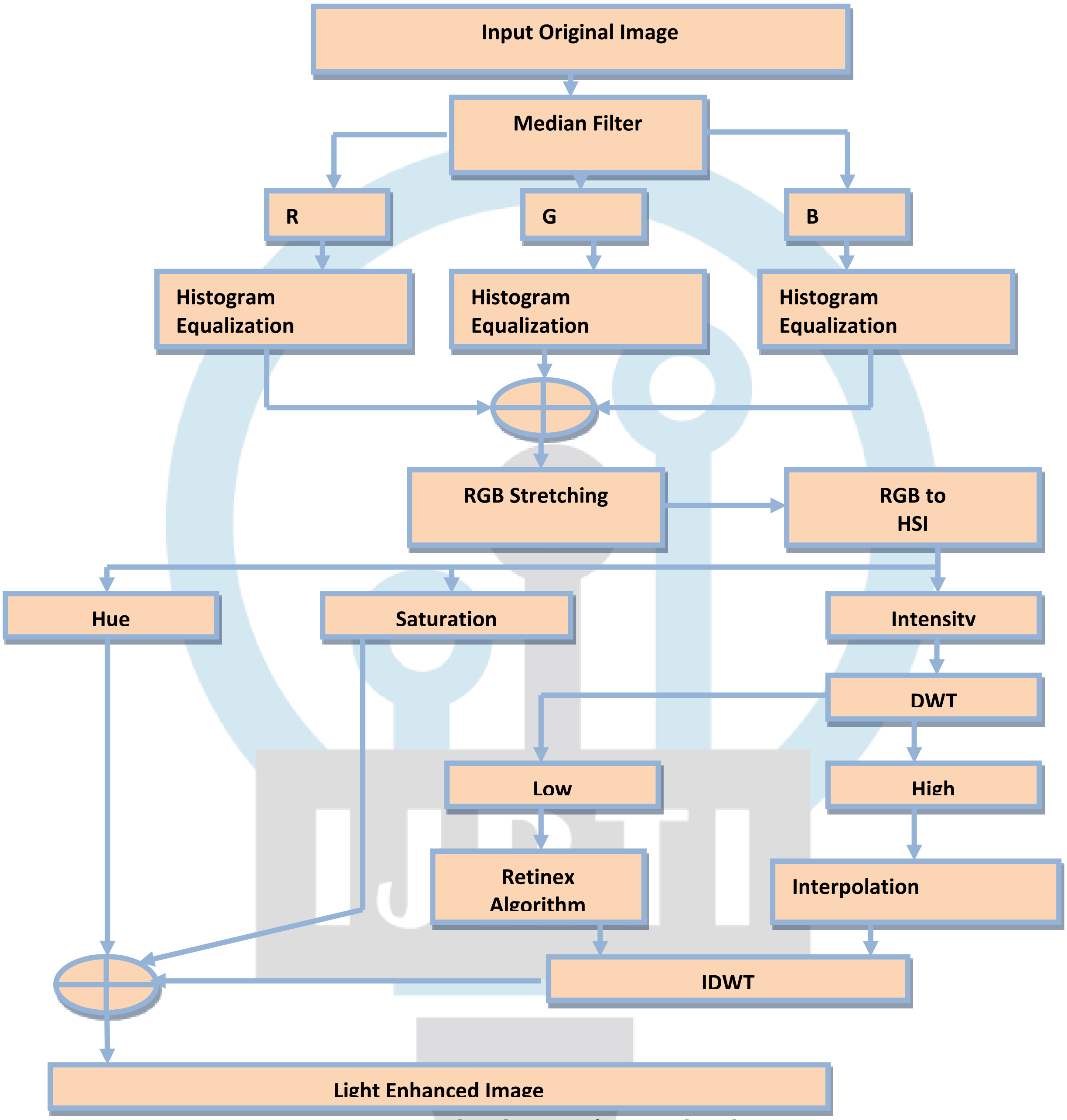

Figure 1 Flow diagram of proposed work

Table 1 Histogram 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	Na= floor(K*F1/9)	$Nb = floor\left[\left\{\frac{f1+f2}{9}\right\} * K\right]$		$Nc = floor\left[\left\{\frac{f1+f2+f3}{9}\right\} * K\right]$	
		$Nd = floor\left[\left\{\frac{f1+f2+f3+f4}{9}\right\} * K\right]$		$Ne = floor\left[\left\{\frac{f1+f2+f3+f4+f5}{9}\right\} * K\right]$	

$$\mathrm{I_e} = \begin{bmatrix} \mathrm{Na} & \mathrm{Nb} & \mathrm{Na} \\ \mathrm{Nc} & \mathrm{Nd} & \mathrm{Nb} \\ \mathrm{Nd} & \mathrm{Nb} & \mathrm{Ne} \end{bmatrix}$$

$\mathrm{I_e}$Is the intensity frame of HSI image of MxN DWT applied on ‘I’
Table 1 below shows the symlet type 4 HPF and LPF filter coefficients. Proposed work use ‘sym4’ type wavelet for decomposition of Cover image, figure 1 below shows HPF and LPF decomposition using DWT.
Table 2 Sym4 filter coefficients

Sym4	h_0 = -0.0757657148, h_1 = -0.0296355276 h_2 = 0.4976186676, h_3 = 0.8037387518 h_4 = 0.2978577956, h_5 = -0.0992195436 h_6 = -0.0126039673, h_7 = 0.0322231006	g_0 = -0.0322231006, g_1 = -0.0126039673 g_2 = 0.0992195436, g_3 = 0.2978577956 g_4 = -0.8037387518, g_5 = 0.4976186676 g_6 = 0.0296355276, g_7 = -0.0757657148

$$\mathrm{I_e}(\boldsymbol{n})_{\boldsymbol{L}} = \sum_{\boldsymbol{k}=-\infty}^{\infty} \mathrm{I_e}(\boldsymbol{k})\boldsymbol{g}(\mathbf{2}\boldsymbol{n}-\boldsymbol{k})$$

$$\mathrm{I_e}(\boldsymbol{n})_{\boldsymbol{H}} = \sum_{\boldsymbol{k}=-\infty}^{\infty} \mathrm{I_e}(\boldsymbol{k})\boldsymbol{h}(\mathbf{2}\boldsymbol{n}-\boldsymbol{k})$$

$$\text{let } \mathrm{I_e}(\boldsymbol{n})_{\boldsymbol{L}} = \mathrm{p}$$

$$\text{let } \mathrm{I_e}(\boldsymbol{n})_{\mathrm{H}} = \mathrm{q}$$

Retinex: let (x,y) are the pixels coordinates of ‘p’ in space domain
then W is the reflection component and Z illumination component then

$$\mathrm{p(x,y) = W(x,y)Z(x,y)}$$

$$where Z(x,y) = \sum_{r=-\infty}^{\infty}\sum_{s=-\infty}^{\infty} F(r,s).p(x-r,y-s)$$

$$F(x,y) = \lambda.e^{\frac{-(x^2+y^2)}{c}}$$

Where c is Gaussian scale is a constant that makes F(x, y) equal to 1.

$$\mathrm{p(x,y) = W(x,y)\{F(x,y) * p(x,y)\}}$$

$$w(x,y) = log_{10}(W(x,y)) = log_{10}(p(x,y)) - log_{10}(F(x,y) * p(x,y))$$

$$w(x,y) willbetheratinexenhanceof p(x,y)$$

let (u,v) are the pixels coordinates of ‘q’ in space domain
Fuzzy Enhancement

$$F_{(u,v)} = \frac{q_{(u,v)} - q_{min}}{q_{max} - q_{min}}$$

$$NF_{(u,v)} = \frac{1}{2} + \left(F_{(u,v)} - \frac{1}{2}\right)^{\frac{1}{3}}$$

$$MF_{(u,v)} = NF_{(u,v)}(q_{max} - q_{min}) + q_{min}$$

$$Mq = MF_{(u,v)} * q_{(u,v)}$$

Mq is the final enhanced high frequency component q

$$\mathrm{Mod\_I} = \sum_{n=-\infty}^{\infty} \left\{Mq\left(\frac{n}{2}\right)_L \pm W\left(\frac{n}{2}\right)_H\right\}$$

III-RESULTS

Parameters for the valuation of the work are Peak Signal to Noise Ratio (PSNR),Mean square error (MSE), Mean, Standard Deviation (STD), Gradient (Grad), Entropy (Ent) and Lightness order error (LOE)

MSE: Mean square error is the error estimation between two image and PSNR is the error amount in the image, MSE can be computer as below

$$\mathrm{MSE} = \frac{1}{\mathrm{rc}}\sum_{i==1}^{\mathrm{RW}}\sum_{j=1}^{\mathrm{CL}}(\mathrm{x_{ij}} - \mathrm{y_{ij}})^2$$

Where 'r' is the number of rows in the image 'c' is the columns in the image x is input image before data hiding, y is the output image after data hiding.
PSNR: Peak Signal to Noise Ratio can be computed as

$$\mathrm{PSNR} = 20\log_{10}\left(\frac{256^2}{\mathrm{MSE}}\right)$$

Mean: The mean, indicated by μ (a lower case Greek mu), Mean [1, 2] is most basic of all statistical measure. Means are often used in geometry and analysis; a wide range of means have been developed for these purposes. In contest of image processing filtering using mean is classified as spatial filtering and used for noise reduction. In this section we have discussed about various type of mean and analyzed their use for removing various type of noise in image processing

$$\boldsymbol{\mu} = \frac{1}{\mathrm{rc}}\sum_{i==1}^{\mathrm{RW}}\sum_{j=1}^{\mathrm{CL}}\mathrm{x_{ij}}^2$$

Standard Deviation (STD): It is a most widely used measure of variability or diversity used in statistics. In terms of image processing it shows how much variation or "dispersion" exists from the average (mean, or expected value). A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data points are spread out over a large range of values. Mathematically standard deviation is given by

$$STD = \sqrt{\frac{1}{rc-1}\sum_{i=1}^{RW}\sum_{j=1}^{CL}\left(x_{ij} - \frac{1}{rc-1}\sum_{i=1}^{RW}\sum_{j}^{CL}x_{ij}\right)^2}$$

Gradient (Grad): An image gradient is a directional change in the intensity or color in an image. The gradient of the image is one of the fundamental building blocks in image processing.

$$grad = \frac{1}{rc}\sum_{i=1}^{RW}\sum_{j=1}^{CL}x_{ij} - x_{i(j-1)}$$

Entropy (Ent): Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image

$$Ent = \sum_{i=1}^{RW}\sum_{j=1}^{CL}p_{ij}log_2p_{ij}$$

Where p_{ij} is the histogram of the image x_{ij}
Lightness order error (LOE): LOE measure is based on the lightness order error between original image X and enhanced image Y .The LOE measure is defined as

$$LOE = \sum_{i=1}^{RW}\sum_{j=1}^{CL}RD_{ij}$$

RD_{ij} is the relative order difference

$$RD_{ij} = \sum_{i=1}^{RW}\sum_{j=1}^{CL}\left(U\left(L_x, L_{ij_x}\right)\oplus U(L_y, L_{ij_y})\right)$$

the lightness L of an image is the maximum of its three color channel.

$$L = MAX_{(r,g,b)}(X_{ij})$$

Propose work has better PSNR and low MSE as compare to available work with modified image.
Simulation is been taken for five test images 'house', 'Tower', 'Boy', office1' and office2'

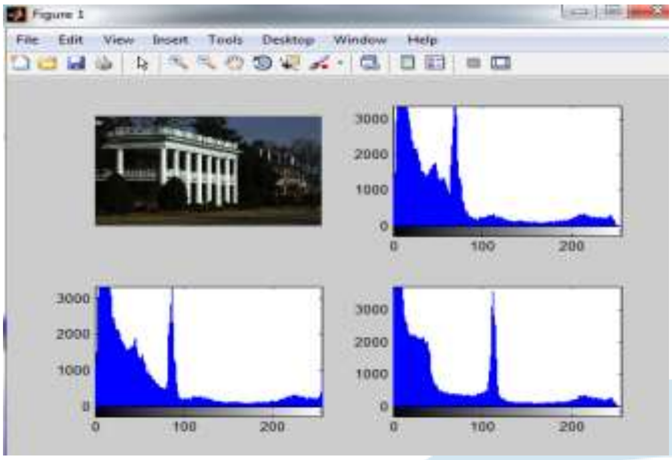

Figure 2 Histogram analysis of test image ‘house’

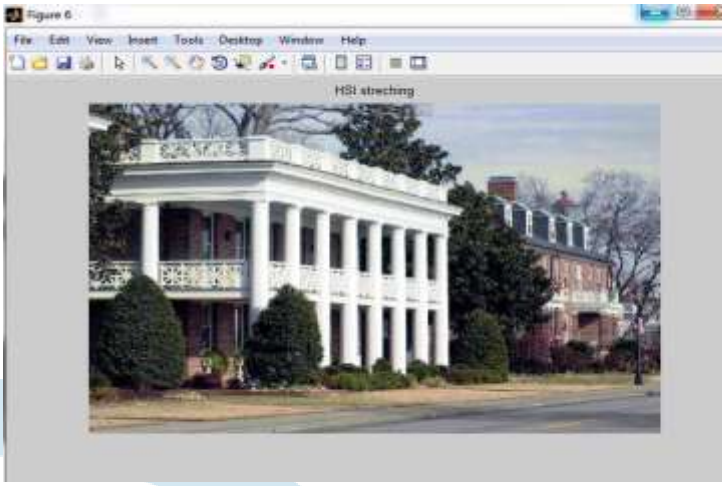

Figure 3 Enhanced test image ‘house’

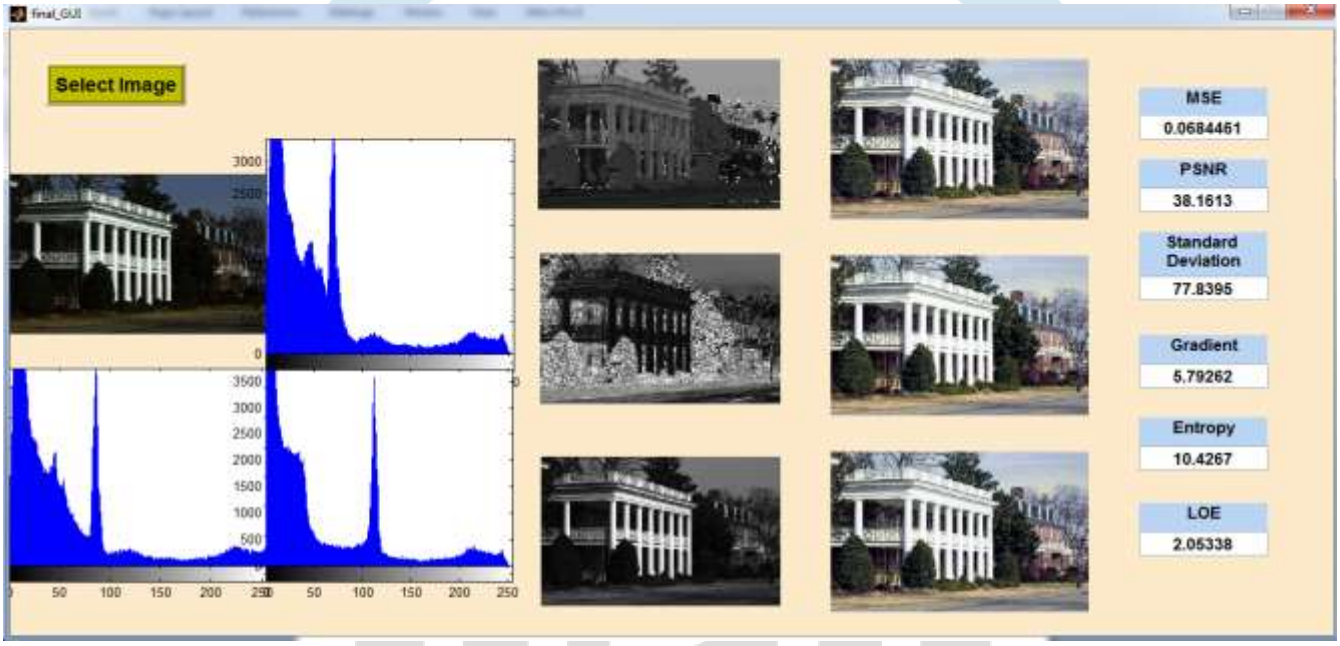

Figure2GUI for the test image House

Table 2 observe results of MSE, PSNR, Standard Deviation, Gradient, Entropy and Light of Error

SN	Test Image	MSE	PSNR	Standard Deviation	Gradient	Entropy	Light of Error
1	House	0.0684461	38.1613	77.8395	5.79262	10.4267	2.05338
2	Tower	0.0494106	35.3308	77.1768	5.30009	9.54017	1.48232
3	Boy	0.0810616	39.6307	77.5506	5.40346	9.72622	2.43185
4	Office1	0.0556062	36.3568	77.7115	5.40103	9.72185	1.66819
5	Office2	0.0482492	35.1242	79.145	5.33087	9.5955	1.44748
	Average	0.0602	36.91	77.88	5.44	9.79	1.812

Table 3 observe results of MSE, PSNR, Standard Deviation, Gradient, Entropy and Light of Error for Fan Wu work

SN	Test Image	MSE	PSNR	Standard Deviation	Gradient	Entropy	Light of Error
1	House	0.0256542	29.6375	78.8366	29.5741	7.39352	2.56542
2	Tower	0.0300877	31.0221	58.149	15.1289	3.78222	3.00877
3	Boy	0.0510899	35.6211	75.5578	25.3882	6.34706	5.10899
4	Office1	0.0371311	32.8491	65.133	18.8384	4.7096	3.71311
5	Office2	0.035199	32.385	66.5693	18.7408	4.6852	3.5199
	Average	0.03248	32.854	69.05	19.19	5.582	3.7584

table 2 above shows the results which we observe for the MATLAB test images of 'house', 'Tower', 'Boy', office1' and office2' for the proposed work, in table 3 we also develope the work proposed by Fan Wu and also compare difference between their work implementation and proposed work implementation and it can be observe that proposed work has better in all parameter for all test images.

Table 4 Comparative result

Work	LOE	MSE	PSNR	Standard Deviation	Gradient	Entropy
Proposed	1.812	0.0602	36.91	77.88	5.44	9.79
Xiaojie Guo / IEEE transactions/2016	2.394					
Zhenqiang Ying/ICCV-IEEE 2015	3.45					
Takuya Mikami/ ICIP 2014		0.29	36.24			
Hyo-Gi Lee/ APSIPA ASC 2015		0.35	38.8703			
Fan Wu / IEEE Proceeding/2017				77.05	29.19	7.87
Xiankun Sun/Sensors-2015				72.95		6.27
Zhuang Feng/IEEE 2017						7.15

Form the above table 4 it can be observe that proposed work is best in parameters of MSE, PSNR, LOE, Standard Deviation, Gradient and Entropy with all other work for the genuine comparison we have choose the same images which was selected by base works.

III- CONCLUSION

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 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, 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 gradient, standard deviation, 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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