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# Lightness enhancement by sigmoid function

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**Abstract**

In this paper we purposed algorithm to enhancement the contrast and lightening of Color image .it is use to solve the problem of low lightening or non-uniform lightening. The purposed algorithm is called (Lightening Enhancement by Sigmoid Function) " LESF", this algorithm consist of three parts the first Adaptive luminance enhancement second contrast enhancement and third Color restoration. This algorithm compared with other algorithm like (A new nonlinear adaptive enhancement) (NNAE), MSR( multi-scale Retinex ) and Histogram equalization (HE).when we compared this algorithm by using entropy, time , Mean Squared Error for hue(Mea-H) and Mean Squared Error for saturation(Mea-S) , we find The result of (LESF) have a good result and better visual Comparing to the other methods

**Keywords:** Image Enhancement, adaptation sigmoid function histogram equalization , Illumination enhancement.

## 1. Introduction

The study of image enhancement to improve visual quality has gained increasing attention and become an active area in image and video processing [1].The Color images obtained by image acquisition devices like digital camera usually suffer from certain defects, such as low or high intensity with poor contrast and noises, and these defects result in poor visual quality. The principle objective of image enhancement is to process an image so that the result is more suitable than the original image for specific applications. Up to now, image enhancement has been applied to varied areas of science and engineering, such as atmospheric sciences, astrophotography, biomedicine, computer vision, etc. [2],[3] Many image enhancement techniques have been proposed to improve the quality of degraded images captured in varying circumstances like Histogram-based(HE) , Retinex-based method s [4] and **The( NNAE) algorithm**[6]

**HE** technique is simple but widely-used for image enhancement. Since conventional HE algorithms may result in over enhancement, many algorithms with restrictions, such as brightness preservation [7], and contrast limitation [8], have been proposed. Brightness preservation is useful in the applications that need to preserve the intensity. However, for non-uniform illumination images, brightness preservation is disadvantageous to detail enhancement in the areas of inappropriate intensity, such as the dark areas. Contrast limited algorithms restrain over-enhancement by redistributing the histogram in such a way that its height does not go beyond the clip limit. But, it is not easy to fix the clip limit for the images of seriously non-uniform illumination, in which the histograms of different areas are quite different. the defects of this algorithm false color .

**Retinex**[4] Theory assumes that the sensations of color have a strong correlation with reflectance, and the amount of visible light reaching observers depends on the product of reflectance and illumination [8]. Most

Retinex-based algorithms extract the reflectance as the enhanced result by removing the illumination, and therefore they can enhance the details obviously. But it is impossible to exactly remove the illumination for the scenes of unsmooth depth. Some center/surround algorithms take the local convolution of the lightness instead of the illumination without considering the limit of the reflectance. In fact, the reflectance should be within [0] [1], which means the surface cannot reflect more light than that it receives. Moreover, it is unreasonable to simply remove the illumination which is essential to represent the ambience [9] the defects of this algorithm is the halo effect[ 5].

**NNAE [6 ]** It is presented to resolve the problem in parallel procedure for Low or High Intensity and Poor Contrast (LIPC or HIPC) images. The NNAE algorithm consists of three steps. First, a RGB color image is converted to an intensity image, then an adaptive intensity adjustment with local contrast enhancement is performed parallelly, by using a single scale shift-variant Gaussian bilateral filter and the second order Taylor series expansion approximation technology, and finally colors are restored .it is have a good enhancement but the defect it is in time (have along time run)

*1.1* purposed method

*LEASF* (lightening enhancement by adaptation sigmoid function) algorithm This a algorithm it use to improve the optical quality of digital images captured under extremely low or non-uniform lightening conditions. It is have three head point:

1- *Adaptive luminance enhancement*
2- *contrast enhancement*
3- *Color restoration*

The three point can explain it as follows.

*1-Adaptive luminance enhancement***:**

The first point of this algorithm is be made up of two part

A-is luminance estimation to obtain by conversion of the luminance information by below equation

$$I = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.270 & -0.322 \\ 0.211 & -0.253 & 0.312 \end{bmatrix} \qquad (1)$$

$$I(x,y) = L(x,y)R(x,y) \qquad (2)$$

Where

$R(x,y)$ is the reflectance and

$L(x,y)$ is the illumination at each position $(x,y)$.

The luminance $L$ is assumed to be contained in the low frequency component of the image while the reflectance $R$, mainly represents the high frequency components of the image. For estimation of illumination, the result of Gaussian low-pass filter applied on the intensity image is used. In spatial domain, this process is a 2D discrete convolution with a Gaussian kernel which can be expressed as:

$$I_c(x,y) = L(x,y) = I(x,y) \otimes F(x,y,c) \qquad (3)$$

F is the Gaussian convolution function[ 13]

The $I_c$ is image convolution.

The second steep use the sigmoid equation as show below to enhancement The Illumination

$$C = \frac{1}{\sqrt{1+\left(\frac{1-I_n}{I_n}\right)}} \qquad (5)$$

$I_n$ normalized

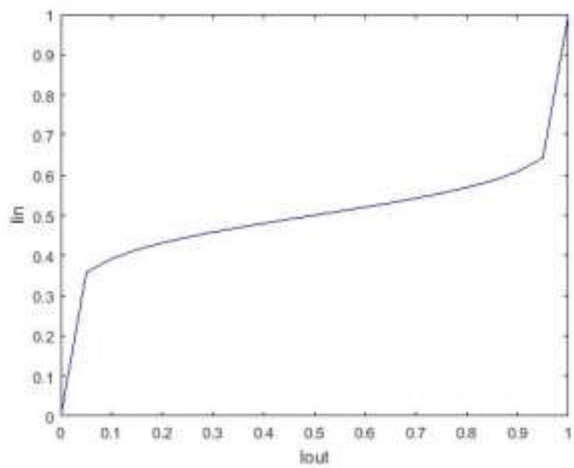



*Figure 1: Relationship between input lightness versus output lightness in ASF* (adaptation sigmoid function[14]).

***2- contrast enhancement***:

The second point of this algorithm, is, done by Center-surround contrast enhancement using:

$$R = I \otimes R_i \qquad (6)$$

$$R_i = W_i \, S_i \qquad (7)$$

$$S_i = 255\,(I_{C_n})^{F_i} \qquad (8)$$

$$F_i = \frac{R_i}{I} \qquad (9)$$

Where

$i = 1,2,3, \ldots$ represents for the *( red ,green, blue) components*

$w_i$ is the weight factor for each constant enhancement .

where $w_1=w_2=w_3=1/3$.

*3-Color restoration*:

a linear color restoration process is applied, it is based on the chromatic information of the original image it is applied to convert the enhanced intensity image to RGB color image .The $(r_e, g_e, b_e)$ of the restored color image are obtained by:

$$C_e(i,j,k) = C(i,j,k)R_K \qquad (10)$$

Where $k$ = 1 2 3 represents for the *( red ,green, blue) components*

$$r_e = \frac{R}{I}r, b_e = \frac{R}{I}b, g_e = \frac{R}{I}g, \qquad (11)$$

Figure (1) show steps of LESF algorithm that is done by the following:

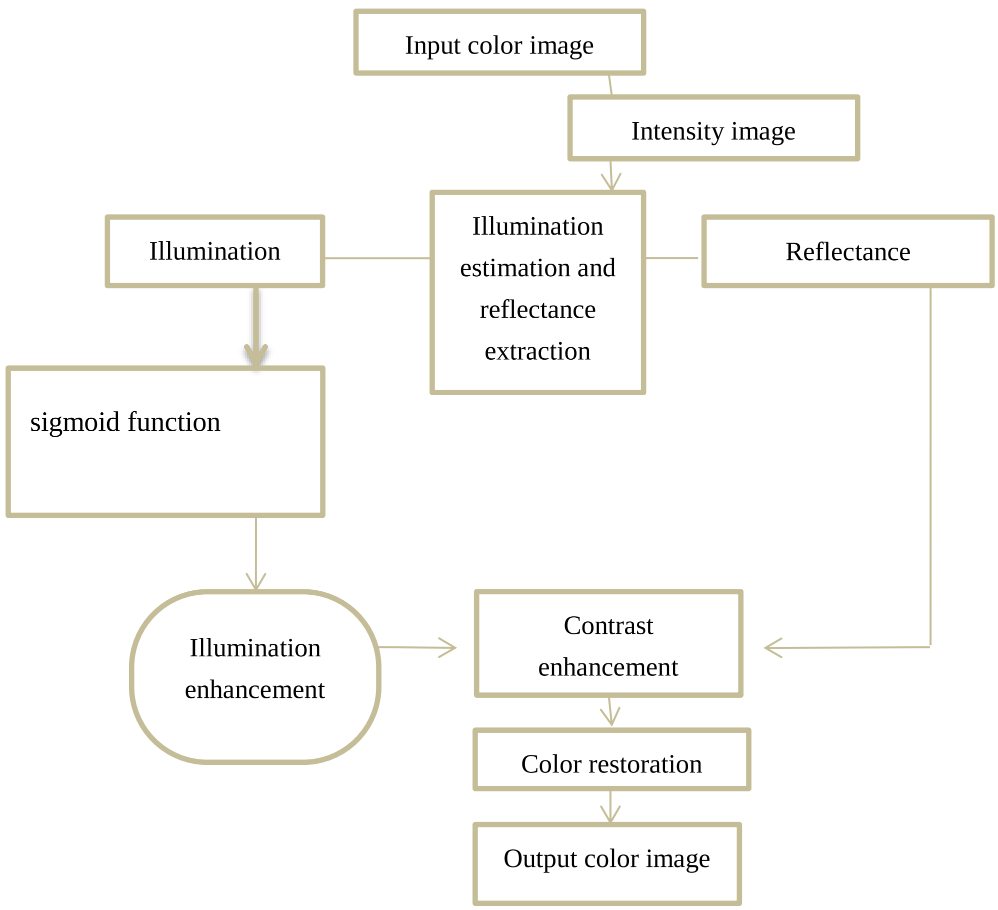



*Figure 2: The diagram of LESF algorithm*

Steps of algorithm

1. *Input color image* $I(x, y)$.

2 *Illumination estimation lightness* $I(x, y)$.

3. *Normalize the lightness component* $I_n(x, y) = I(x, y)/255$ .

4. *Calculate the mean value and put it in Q equation(4)*

*5. Calculate the sigmoid function* $C = \frac{1}{\sqrt{1+\left(\frac{1-I_n}{I_n}\right)}}$

*7. Compute reflectance image from* $S_i = 255\,(I_{C_n})^{F_i}$

*8. Output the image result from components* $r_e = \frac{R}{I} r, b_e = \frac{R}{I} b, g_e = \frac{R}{I} g,$

**1.1.1 Quality assessment**

In this research use non - chromatic compounds (V) and when calculating quality in chromatic compounds like (H)and(S)

**1-Entropy.[9]**

it is used to measure the quality of image. Images which have maximum entropy have the better quality of the image . we use the visual (V) which it is subsists of HSV Color Model .

$$\text{Ent (V)} = -\sum_{l=0}^{l-1} p(v)\log p(v) \qquad (12)$$

Where

Ent = entropy of the image.

$p(v)$ = probability density function at intensity level v.

v= total number of gray level

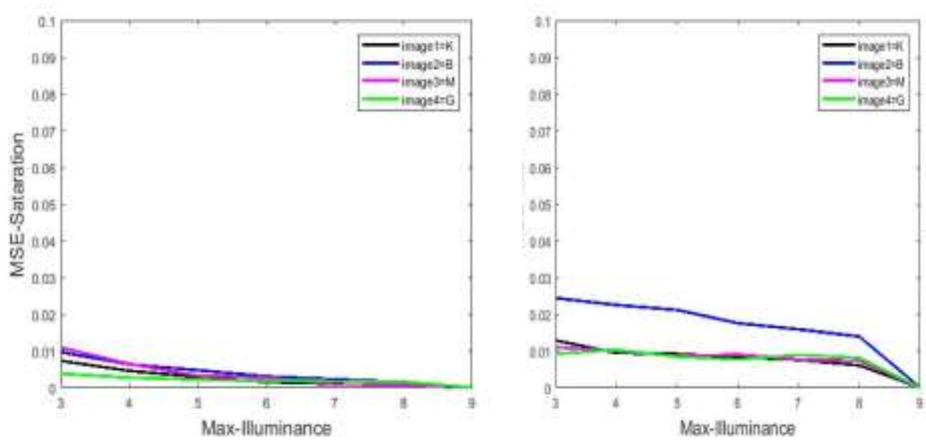



*Figure 3: Relationship between the illumination and mean square err to (hue and saturation ) .*

**2-Mean Squared Error:**

In this part we are calculating The MSE for hue (H) and for , saturation (S)

$$\text{MSE (H)}= \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}((H_n(x,y)-H(x,y))^2 \quad (13)$$

$$\text{MSE (S)}= \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}((S_n(x,y)-S(x,y))^2 \quad (14)$$

**1.1.2Computational speed evaluation**

In this work we are using Matlab version (R2017a) on the plat –form of Intel Core5 processor, running at 2.00 GHz with 4 GB of memory, with number of color test image with different size. we see the processing time of (LESF ) is less than NNAE about 85% ,but the other method it is less than (LEASF ) because this methods have some defects like halos , err in Distribution of lighting in the picture and the quality of the color in test image not perfect as show in (LESF ) in the image test .

1.1.**3 RESULTS AND DISCUSSIONS**

In this section we will obtained the results of purpose method and Discussions the results of this paper .in this paper we take the popular image , our data base of image it is about 10 by[4] and 6 captured by using Nikon D7000 digital camera, all the images have low lightness and non-uniform lightness, Simulation experiments have been conducted on the test images figures (3-8) with type Jpg, and size of image 750×387, 750×491 and 750×725pixels.. this algorithm compared with two conventional algorithms , HE [7],MSR [4], and the recently the algorithms (NNAE)[5]. By using Matlab software program and to simulate the proposed method which based on adaptation sigmoid function and association of different methods together we get some result which help as to find the advantages of these methods and techniques on the poor lightness images. In this work we first test the algorithms from the subjective aspect, and then perform objective assessment, using the entropy[9], time , Mean Squared Error for hue and saturation. The processed results of the selected images are shown in Table . 1–6.

Subjective Assessment

it is depended on human visual system for that we will see some defects in all purposed algorithms . the image tested MSR it have halo effect as show in figures (3(e)-8(e)) , the test image enhancement by HE it is have false color as show in figures (3(f)-8(f)), NNAE it is have little false color as show in figures (3(f)-8(f))

objective assessment

As subjective assessment depends on human visual system, it is hard to find an objective measure that is in accordance with the subjective assessment. Objective assessment is often used to explain some important characteristics of the image [12], [13]. We assess the detail enhancement through the entropy[9], time , Mean Squared Error for saturation and Mean Squared Error for hue] . in all figures( 3a-7a) the entropy is good for the image as show in the

Table( 1-5)( LESF) it is have the high value that mean a good enhancement and the other method it is have less than the( LESF). the other Objective assessment Mean Squared Error for saturation and Mean Squared Error for hue , this assessment depends on the a smaller amount value or the value are equal depends on the figure (9) ,(it is mean a good result ) as show in all figures( 3-8) and the Table (1-6)

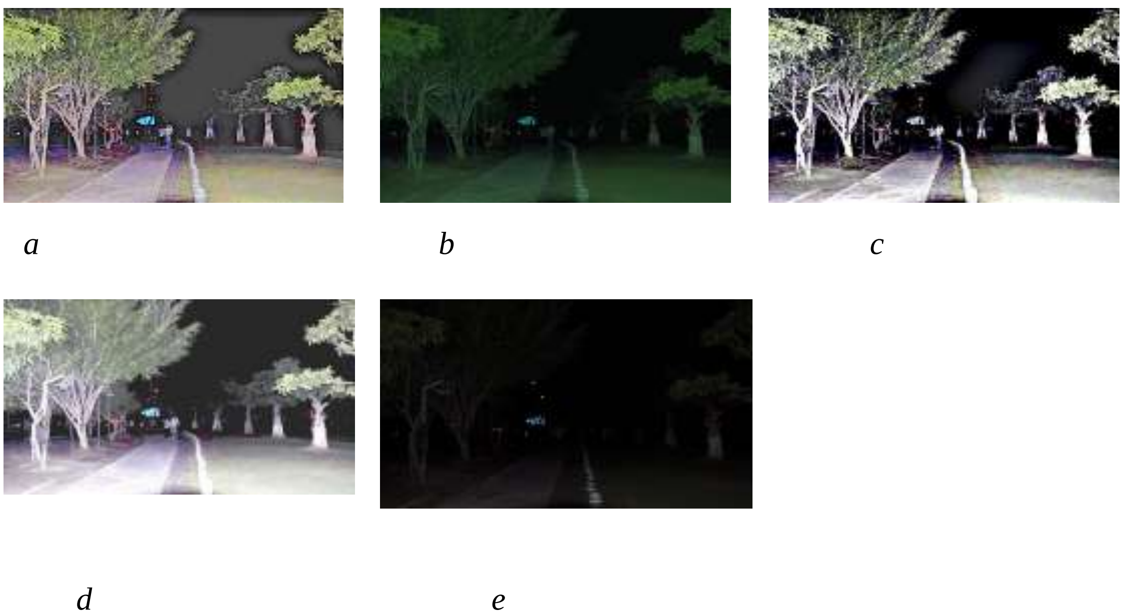
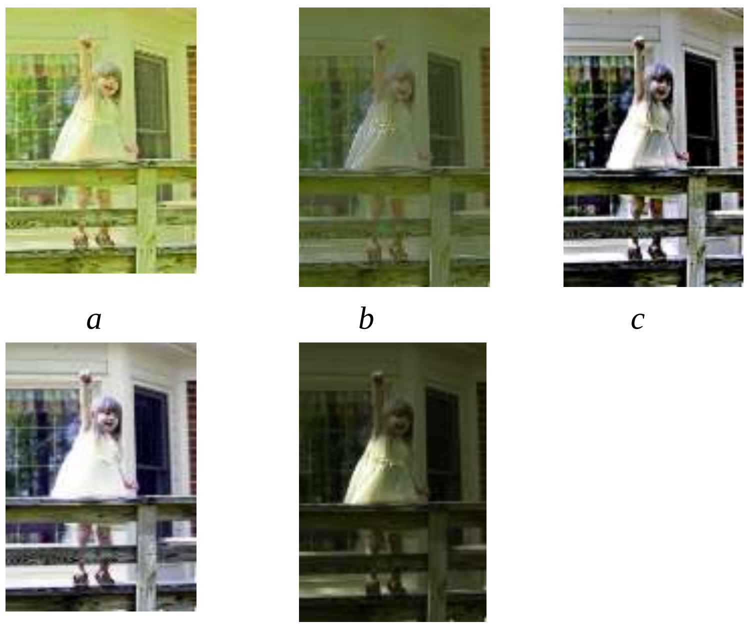



*Fig3.* : Results for image *Sculpture*. (a) Enhanced image LE SF. (b) Enhanced image of NNAE (c) Enhanced image of MSR (d) Enhanced image of HE(e) Original image

*Table 1 The quantity of the quality assessment for all methods*

| Method | Tim | Mse H | Mse S | Entropy |
|---|---|---|---|---|
| LE SF(a) | 2.18271 | 7.73E-06 | 2.99E-05 | 7.333048 |
| NNAE(b) | 34.1626 | 0.118852 | 0.111702 | 5.743861 |
| MSR (c) | 1.272439 | 0.136598 | 0.107969 | 5.79673 |
| HE(d) | 0.033501 | 0.086831 | 0.023434 | 4.529517 |



*a* *b* *c*

*d* *e*

*Fig4* Results for image *Sculpture*. (a) Enhanced image LE SF. (b) Enhanced image of NNAE (c) Enhanced image of MSR (d) Enhanced image of HE(e) Original image

*Table 2 The quantity of the quality assessment for the all methods*

| Method | Tim | Mse H | Mse S | Entropy |
|---|---|---|---|---|
| LE SF(a) | 1.47452 | 2.05E-06 | 4.41E-06 | 7.675305 |
| NNAE(b) | 20.82369 | 0.0015 | 0.00058 | 7.041269 |
| MSR (c) | 0.974505 | 0.081845 | 0.161405 | 6.513976 |
| HE(d) | 0.033847 | 0.116861 | 0.106073 | 5.964315 |

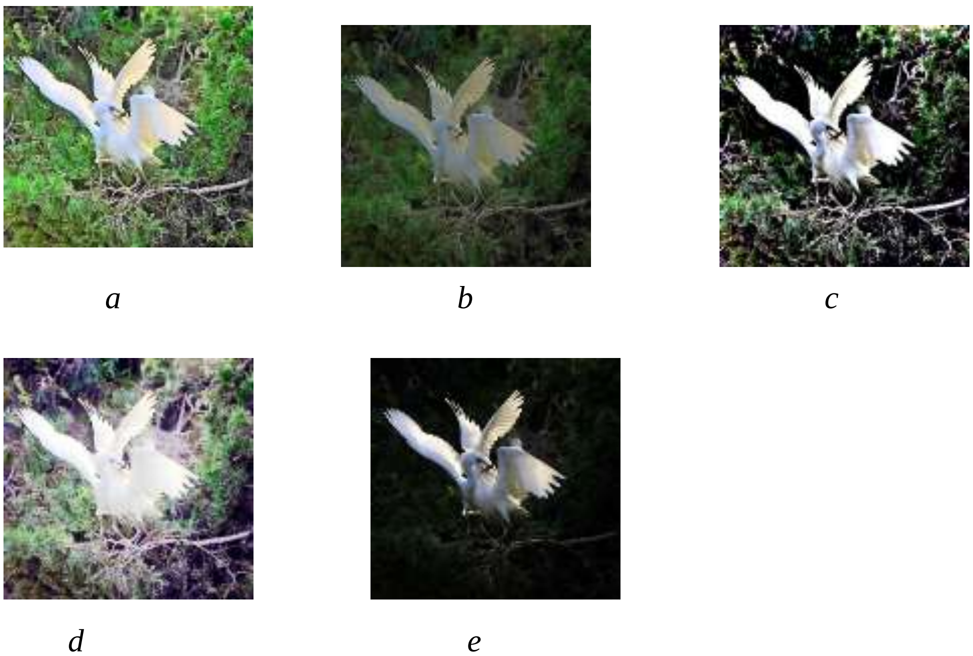
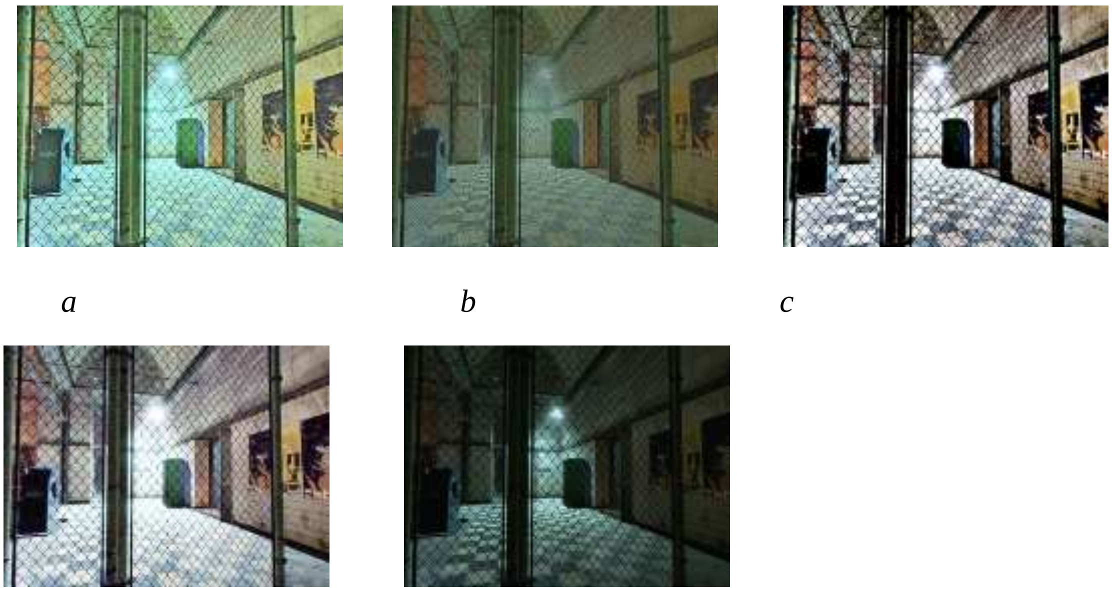



Figure 5 Results for image *Sculpture*. (a) Enhanced image LE SF. (b) Enhanced image of NNAE (c) Enhanced image of MSR (d) Enhanced image of HE(e) Original image

*Table 3. The quantity of the quality assessment for the all methods*

| Method | Tim | Mse H | Mse S | Entropy |
|---|---|---|---|---|
| LE SF(a) | 1.759084 | 7.86E-06 | 5.89E-05 | 7.79213 |
| NNAE(b) | 27.58079 | 0.017204 | 0.00312 | 7.095469 |
| MSR (c) | 1.070507 | 0.094744 | 0.182908 | 4.706457 |
| HE(d) | 0.031693 | 0.192774 | 0.104027 | 5.582275 |



*a* *b* *c* *d* *e*

*Fig6* Results for image *Sculpture*. (a) Enhanced image LE SF. (b) Enhanced image of NNAE (c) Enhanced image of MSR (d) Enhanced image of HE(e) Original image

*Table 4 The quantity of the quality assessment for the all methods*

| Method | Tim | Mse H | Mse S | Entropy |
|---|---|---|---|---|
| LE SF(a) | 1.002966 | 2.95E-06 | 8.67E-06 | 7.801445 |
| NNAE(b) | 17.04271 | 0.00503 | 0.003654 | 7.391223 |
| MSR (c) | 0.755945 | 0.107978 | 0.10535 | 6.038356 |
| HE(d) | 0.028976 | 0.102494 | 0.048463 | 5.941678 |

*a* *b* *c*

*d* *e*

Figure 7 : Results for image *Sculpture*. (a) Enhanced image LE SF. (b) Enhanced image of NNAE (c) Enhanced image of MSR (d) Enhanced image of HE(e) Original image

*Tabel-5 The quantity of the quality assessment for the all methods*

| Method | Tim | Mse H | Mse S | Entropy |
|---|---|---|---|---|
| LE SF(a) | 16.32116 | 6.59E-06 | 8.27E-05 | 7.373549 |
| NNAE(b) | 126.802 | 0.001404 | 0.000133 | 7.018378 |
| MSR (c) | 6.239735 | 0.042172 | 0.096747 | 6.952587 |
| HE(d) | 0.424351 | 0.097608 | 0.040278 | 5.927107 |

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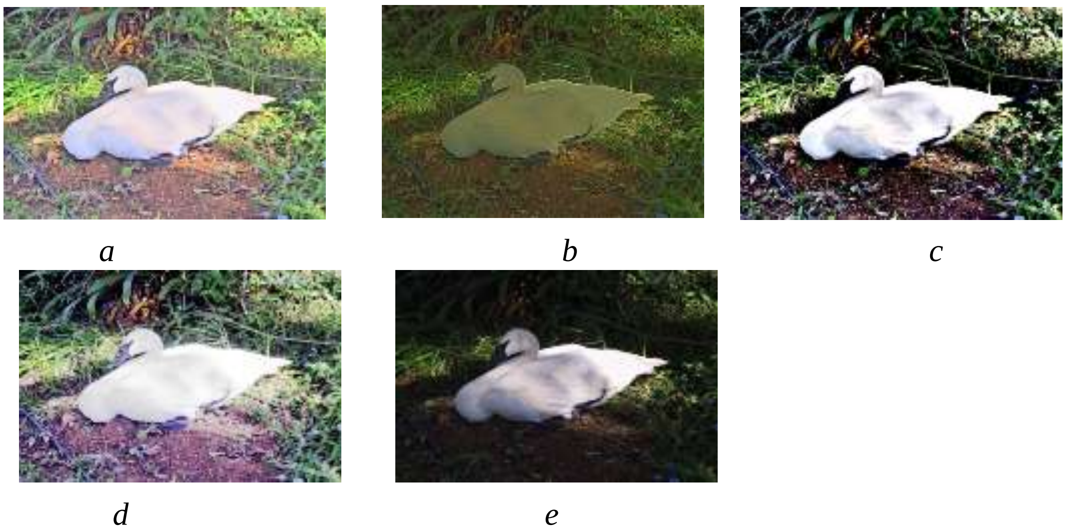


*Fig 8.*:Results for image *Sculpture*. (a) Enhanced image LE SF. (b) Enhanced image of NNAE (c) Enhanced image of MSR (d) Enhanced image of HE(e) Original image

*Tabel-6 The quantity of the quality assessment for the all methods*

| Method | Tim | Mse H | Mse S | Entropy |
|---|---|---|---|---|
| LE SF(a) | 0.530856 | 9.93E-06 | 0.000145 | 7.711589 |
| NNAE(b) | 9.620076 | 0.164412 | 0.075197 | 6.979309 |
| MSR (c) | 0.413748 | 0.160871 | 0.138913 | 5.620045 |
| HE(d) | 0.025754 | 0.16415 | 0.057035 | 5.869769 |

### 1.1.4Conclusion

This paper proposes a color image enhancement technology to enhancement the lightness and keep the details of this picture. it is compared with other method or algorithm such (NNAE),(Ret)and (HE). We see the (LESF) have a good result and better visual Comparing to the other methods, depending on the subjective and Objective assessment . result as obtained the proposed algorithm it is well.

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