Color Image Enhancement using Modify Retinex and Histogram Equalization Algorithms Depending on a Bright Channel Prior

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ABSTRACT

In this paper the color images with low lightness has been enhanced by using Modified Retinex and histogram equalization (MRHE) algorithms Dependingon a bright channel prior . This algorithm treats the lightness component in YIQ color space that is transformed using bright channel prior, and then the chromatic components get form traditional Multiscale Scale Retinex algorithm with Color Restoration (MSRCR). Then apply the histogram equalization, after using invers transform,this algorithm enhanced lightness and contrast in all regions with low or high lightness. This algorithm is camper with MSRCR and HE, to examine the efficiency of it, weused the metrics depending on the relationship between the mean and the average of standard deviation for enhancement images.

Keywords: Color image enhancement, Modify Retinex, Histogram equalization, Bright channel prior.

1. INTRODUCTION

The Principle objective of Images enhancement is to process an color image so that result is more suitable than original image for especially application .To solve the problem of images quality decrease [1], a perceptive model of human vision is simulated, combining the typical computational theory of Retinex theory. The reflectivity image of the target surface can be gained by the comparative operation of one pixel with its surrounding pixels. Images had been processed on the base of the "gray world" assumption [2]. A number of researches is conducted to study the contrast and lightness enhancement in color image in different ways, in the following some of these in [2], suggested an algorithm to improve the brightness, contrast and sharpness of an image. It does a non-linear spatial/spectral transform that provides simultaneous dynamic range compression [3]. More advanced image enhancement algorithm has been developed such as Adaptive Histogram Equalization (AHE) [4] and Retinex [5,6]. In general Retinex theory is one of the most appealing approaches for image enhancement and color constancy in color image processing [7,8]. In this study we used the retinex algorithm and histogram equalization to enhancement image depending on YIQ color space and bright channel prior. And we compare this algorithm with another algorithm.

2. HISTOGRAM EQUALIZATION (HE)

HE and its variations have traditionally been used to correct for uniform lighting and exposure problems. This technique is based on the idea of remapping the histogram of the scene to a histogram that has a near-uniform probability density function. This results in reassigning dark regions to brighter values and bright regions to darker values. Histogram equalization works well for scenes that have unimodal or weakly bi-modal histograms (i.e. very dark, or very bright), but not so well for those images with strongly bi-modal histograms (i.e. scenes that contain very dark and very bright regions)[9].This algorithm summarized by using following steps:

1. *Input color image C(n,m,i), i=1,2,3 (red ,green, blue) components.*
2. *Normalize each component $r_j(i)= C(x,y,i)/ 255$ and calculated frequency of occurrence each gradual level $n_j(i)$, where $j=0,1,..255$.*
3. *Compute histogram from $P(r_j(i))=n_j(i) /N$, where N being the size of image.*

4. Calculate cumulative histogram by :

$$s_k(i) = \sum_{j=0}^{k} \frac{n_j(i)}{N} \quad \textit{where } k=0,1,..255 .$$

5. *Replace each* normalized component r_j (i)by value of sk(i) we get the output image .

3. MULTI SCALE RETINEX ALGORITHM

The multiscale retinex (MSR) is explained from single-scale retinex (SSR) we have[2,8]:

$$R_i(x,y,c) = \log[I_i(x,y)] - \log[F(x,y,c) \otimes I_i(x,y)] \qquad (1)$$

Where $R_i(x,y,c)$ the output of channel i (i $\in$ R,G,B) at position x,y , c is the Gaussian shaped surrounding space constant , $I_i(x,y)$ is the image value for channel i and symbol $\otimes$ denoted convolution . $F(x,y,c)$ Gaussian surrounds function that is calculated by[2]:

$$F(x,y,c) = (k)\exp\left(\frac{-(x^2 - y^2)}{c^2}\right) \qquad (2)$$

k is determined by[8]:

$$\iint F(x,y,c)\,dx\,dy = 1 \qquad (3)$$

The MSR output is then simply a weighted sum of the outputs of several different SSR output where[2,10]:

$$R_{MSR}(x,y,w,c) = \sum_{n=1}^{N} W_n R_i(x,y,c_n) \qquad (4)$$

Where N is the number of scales, $R_i(x,y,c_n)$ the i'th component of the n'th scale, $R_{MSR}(x,y,W,c)$ the i'th spectral component of the MSR output and W_n the weight associated with the n'th scale. And we insist that ($\sum W_n = 1$). The result of the above processing will have both negative and positive RGB values, and the histogram will typically have large tails. Thus a final gain-offset is applied as mentioned in [10] and discussed in more detail below. This processing can cause image colors to go towards gray, and thus an additional processing step is proposed in [2]:

$$R' = R_{MSR} . I_i'(x,y,c) \qquad (5)$$

Where I' given by

$$I_i'(x,y,a) = \log\left[1 + a\frac{I_i(x,y)}{\sum_{i=1}^{3} I_i(x,y)}\right] \qquad (6)$$

Where we have taken the liberty to use log(1+x) in place of log(x) to ensure a positive result. In [2] a value of 125 is suggested for (a) second. And the final step is gain-offset by 0.35 and 056 respectively [11]. In this work we used (w1=w2=w3=1/3) and (c1=250,c2=120,c3=80) [2] .

This algorithm done by using following steps:

1. *Input color image $I_i(x,y)$, i= r,g,b .*
2. *Calculate Gaussian surrounds function* $F(x,y,c_n) = (k)\exp\left(\frac{-(x^2-y^2)}{c_n^2}\right)$ *, where k is normalization constant, c_n, n=3, {c_1=250, c_2=120, c_3=80}.*
3. *Compute SSR from* $R_i(x,y,c) = \log[I_i(x,y)] - \log[F(x,y,c_n) \otimes I_i(x,y)]$.
4. *Compute MSR from* $R_{MSR}(x,y,w,c) = \sum_{n=1}^{N} W_n R_i(x,y,c_n)$ *, N=3 {w_1=w_2=w_3=1/3}.*

5. *Calculate MSR with color restoration by:* $I_i'(x,y,a,b) = b\log[1 + a\frac{I_i(x,y)}{\sum_{i=1}^{3} I_i(x,y)}]$ *, b=100, a=125.*

6. *Output image is gotten form gain offset by* $I_{pi}(x,y)=0.35(I_i'(x,y,a,b)+0.56)$.

4. MRHE Depending on bright channel prior

In the MSRCR the color value of a pixel is computed by taking the ratio of the pixel to the weighted average of the neighboring pixels. One disadvantage of this technique is that there could be abnormal color shifts because three color channels are treated independently. An inherent problem in most retinex implementation is the strong 'halo' effect in regions having strong contrast. The 'halo' effects are shown in Figure (1). The 'halo' effects and color shifts are reduced in MRHE algorithm by processing Y component, the steps of it is:

(a) Original (b) Enhanced

Figure 1: Halo effect caused during retinex enhancement can be observed around the edge of the body and the background.

a. Lightness enhancement

Transform color image from basic RGB color space to YIQ color space by used equation [12]:

$$M_{RGB\ to\ YIQ} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.270 & -0.322 \\ 0.211 & -0.253 & 0.312 \end{bmatrix} \quad (7)$$

b. bright channel prior

The bright channel prior we proposed is inspired by K.He's dark channel prior [11].And then transformed normalized lightness value using bright channel prior by used:

$$J^{bright}(x) = \max(J^c(x)) \quad (8)$$

Where C color channel of J image with pixel index x .

c. Chromatic enhancement

The chromatic channels i,q are enhanced by applying MSRCR on the original RGB components after using forward transformation ; this method of processing will decrease the color shift ,but it needs to redefined gain-offset value, in this work used value 0.1 and 0.5, are respectively.

d. Combining enhanced channels

The final step is combining the lightness enhanced component y_p and chromatic enhanced channels ir,qr by using inverse transform[12]

$$\left.\begin{aligned} r &= y_p + 0.956ir + 0.621qr \\ g &= y_p - 0.272ir - 0.647qr \\ b &= y_p - 1.106ir + 1.703qr \end{aligned}\right\} \quad (9)$$

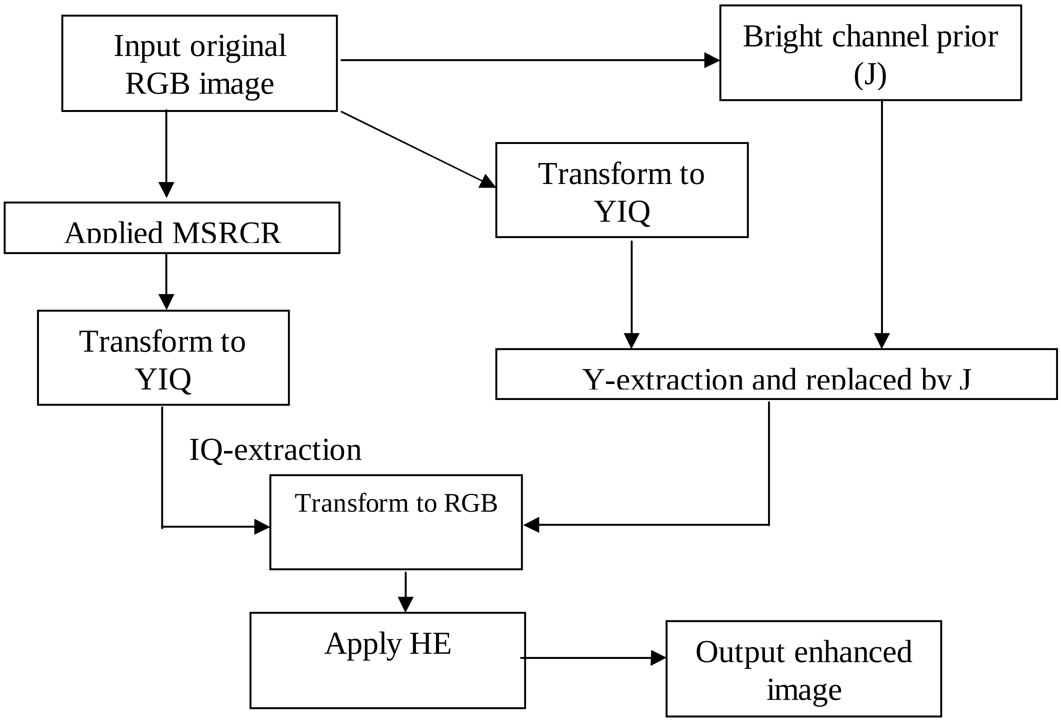


Figure 1: flowchart of (MRHE) algorithm.

To get enhancement components rp ,gp ,bp .Figure (2) shows the summarization steps of the proposed algorithm. We do this by the following steps:

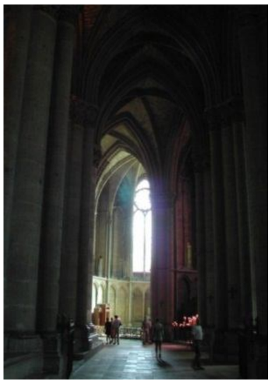
1. *Input color image C(x,y,i), i=1,2,3 (red ,green, blue) components*
2. *Transform color image from RGB color space to YIQ and estimation Y component.*
3. *Normalized Y component by* $I_n = \frac{Y}{255}$.
4. *Transform lightness component by using* $J^{bright}(x) = \max(J^c(x))$ *getting processed lightness component* Y_p.
5. *Apply MSRCR on transformed original image in step1 getting* $R_R G_R B_R$ *components*
6. *Transform color image from* $R_R G_R B_R$ *to YIQ to getting* $Y_R I_R Q_R$.
7. *Collection component* Y_p *and* $I_R Q_R$ *, then applied inverse transformation to basic RGB color space to getting output image.*

5. EXPERIMENT RESULTS

Three images (a , b and c) have been used in this study[13], all image with size (400*600) and type GPJ. All images are processing by Matlab 2013 program and all images are capture under low lightness conduction, these images are illustrated in the first row in figure (3), second row is represent the image enhanced by HE, third row is represent the images enhanced by MSRCR whereas the fourth row is the images enhanced by suggested algorithm MRHE. we can noted by used objective equality assessment the best enhancement was accrued in the MRHE algorithm, it follows the MRHE algorithm and HE .This beavers is reflected in Relationship between mean of local standard deviations and mean in the figure (4) where the point of the suggested algorithm MRHE tend to optimal reign with good contrast and lightness enhancement follows the MRHE algorithm and HE.

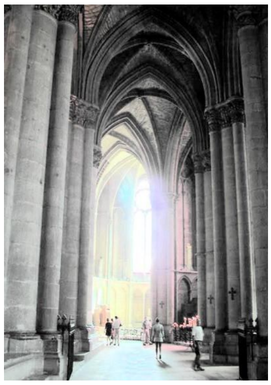

Original -a


Original -b


Original -c


HE -a


HE -b


HE -c


MSRCR -a


MSRCR -b

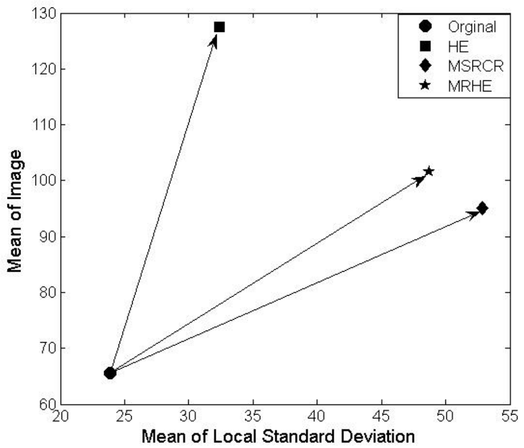

MSRCR -c


MRHE -a

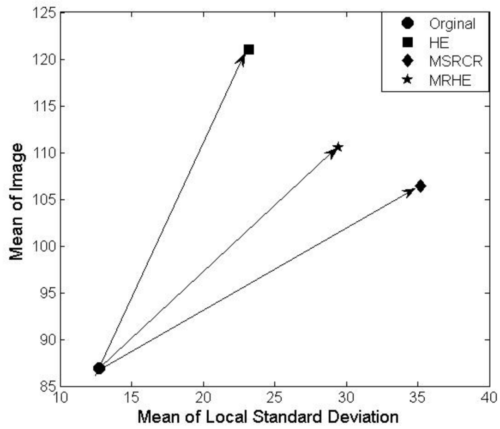

MRHE -b


MRHE -c

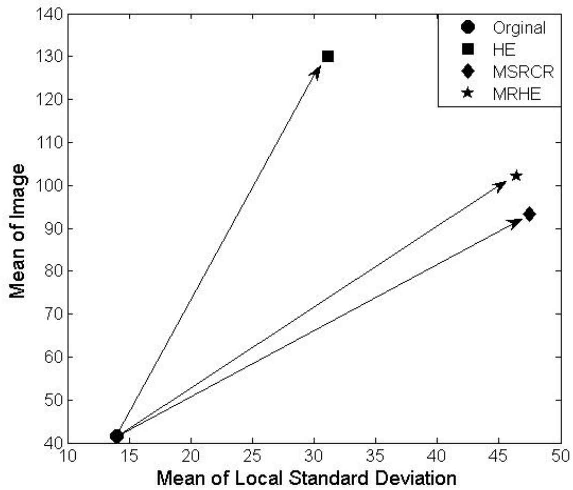
Figure 3: original group images (a, b and c) and the results of the enhanced images, and using, HE, MSRCR and MRHE respectively.



(a)



(b)



(c)

Figure4 : Relationship between mean of local standard deviations and mean of original and enhancement imagesgroup (a) in a, group (b) in band group (c) in c.

6. Conclusion

In this study the low lightness images areenhancement by using HE, MSRCR algorithms and suggested algorithm is MRHE based that is depending on YIQ color space, from the results the MRHE gives better performance in comparison with the others algorithms, depending on equality measures.

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