Night Image Enhancement by Using non Linear Adaptive filter

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Abstract

In this paper, we present a new image enhancement algorithm which is apply to enhance night images or very low luminance images by using Gaussian convolution and adaptive dynamic range compression of intensity that is dependent on non leaner function. This leads a robust algorithm is more resilience and that with low parameter moreover it's improve dark region in digital image by luminance and contrast enhancement called non leaner adaptive NLA filter . The results was compared with Histogram Equalization HE and multi scale retinex MSR algorithm by calculate normalize mean square error NMSR between processed images and original images with fair lightness, histogram of all method enhancement is a account . Adaptive filter has high efficiency in enhanced night image with low lightness compared with other methods.

1. Introduction

There are serious discrepancy existing between the image captured from any digital devices and observation of real scenes. This is due to the fact that the captured image contains the information given by the physical values of light while the human perception has natures of dynamic range compression and color rendition on the scenes [1].

The idea of the retinex as model of lightness and color perception of the human vision first proposed by Land [2] and many researchers [1,3,4] advocates MSR as a method image enhancement that proved color constantly and dynamic range compression . Nonetheless, there are many number of problems with the original MSR method one of them the main practical consequence of this that is not appropriate for application which are sensitive to color [5] and extreme luminance (very dark or very bright regions) in digital image . We use adaptive algorithm dose not change the color in image because the processing done on only the light component and the colors components are conserved and very efficient in enhanced night images. The outline of the paper is as follows: Section 2 shown histogram equalization. Section 3 describes the summary of multi-scale retinex algorithm. Section 4 introduction a new adaptive algorithm. Result and discussion are shown in Section 5, finally conclusion shown in Section 6.

2. Histogram equalization

If lightness levels are continuous quantities normalized to the range (0, 1), $p_r(r)$ denote the probability density function (PDF) of the lightness levels in a given image, where the subscript is use for differentiating between the PDFs of the input and output images. Suppose that we perform the following transformation on the input levels to obtain output (processed) intensity levels[6],

$$s = T(r) = \int_0^r p_r(w)dw \tag{1}$$

Where w is a dummy variable of integration, that the probability density function of the output levels is uniform, that is[6]:

$$P_s(s) = \begin{cases} 1 & for \ \ 0 \leq s \leq 1 \\ 0 & else \end{cases} \tag{2}$$

When dealing with discrete quantities we work with histograms and call the preceding technique histogram equalization, where [6]:

$$s_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j) = \sum_{j=o}^{k} \frac{n_j}{n} \qquad k = 0.....L \tag{3}$$

Where: r_k is normalized intensity level of the input image corresponding to the (un-normalized) intensity level k: $r_k = \dfrac{k}{L}$ (r_k=0..1) and (k =0,1,..L) and L =255 for lightness band with 8 bit/pixel), s_k corresponding normalized intensity level of the output image .The cumulative probability density function (CPDF) calculated by[6]:

$$p_c(r_k) = \sum_{j=0}^{k} p_r(r_j) = \sum_{j=0}^{k} \frac{n_j}{n} \tag{4}$$

r_j is normalized intensity level of the input image corresponding to the (un − normalized) intensity level j , and r_j given by :

$$r_j = \frac{j}{L} \quad , j = 0,1,..L. \tag{5}$$

Where n_j being the number of pixel with intensity j and n is the total number of pixel of the image .

3. Summary of multi-scale retinex algorithm

The multiscale retinex (MSR) is explained from single-scale retinex (SSR) we have [1,3]:

$$R_i(x, y, c) = \log[I_i(x, y)] - \log[F(x, y, c) \otimes I_i(x, y)] \tag{6}$$

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[1]:

$$F(x, y, c) = (k) \exp(\frac{-(x^2 - y^2)}{c^2}) \qquad (7)$$

k is determined by[3]:

$$\iint F(x, y, c) \, dx \, dy = 1 \qquad (8)$$ The

MSR output is then simply a weighted sum of the outputs of several different SSR output where[1,3]:

$$R_{MSR}(x, y, w, c) = \sum_{n=1}^{N} W_n R_i(x, y, c_n) \qquad (9)$$ Wher

e 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 [3] 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 [1]:

$$R' = R_{MSR} * I_i'(x, y, c) \qquad (10)$$

Where I' given by

$$I_i'(x, y, a) = \log[1 + a \frac{I_i(x, y)}{\sum_{i=1}^{3} I_i(x, y)}] \qquad (11)$$

where we have taken the liberty to use *log(1+x)* in place of log(x) to ensure a positive result. In [1] a value of 125 is suggested for (a) second. and the final step is gain-offset by 0.35 and 056 respectively[5]. In this search used ($w_1 = w_2 = w_3 = 1/3$) and ($c_1 = 250, c_2 = 120, c_3 = 80$) [1] .

4. Non liner adaptive filter

The NLA algorithm dependent on adaptive luminance enhancement , contrast enhancement and color restoration . Adaptive luminance enhancement: that is dividing in two steps, first step is luminance estimation to obtain by Conversion of the luminance information by using NTSC (National Television Standards Committee) color space. Intensity or lightness values of RGB image can be obtained as[7]:

$$I(x, y) = 0.298r(x, y) + 0.587g(x, y) + 0.114b(x, y) \qquad (12)$$

Where R,G,B are the red, green, blue components for color images in RGB space at point (x, y). And the Normalization Intensity is[7]:

$$I_n(x, y) = I(x, y)/255 \qquad (13)$$

The image information according to human vision behavior can be simplified and formulated as[7]:

$$I(x, y) = L(x, y)R(x, y) \qquad (14)$$

Where $R(x, y)$ is the reflectance and $L(x, y)$ is the illumination at each position (x, y), the illumination 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. The estimation of the illumination, the Gaussian low-pass filtered result of the intensity image is used. In spatial domain, this process is a 2D discrete convolution with a Gaussian kernel which can be expressed as[1]:

$$I_c(x,y) = L(x,y) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} I(m,n) F(m+x, n+y, c) \qquad (15) \quad I_c \text{ is}$$

image convolution, F is the 2D Gaussian function with size M×N and the Gaussian kernel (mask) is defined in equation (7). And the nonlinear transform of illuminance given by the function is:

$$I'_n = \frac{1}{1 + \sqrt{\dfrac{1}{I_n} - 1}} \qquad (16)$$

This transformation can largely increase the luminance for these dark pixels, figure (1) shown this function.
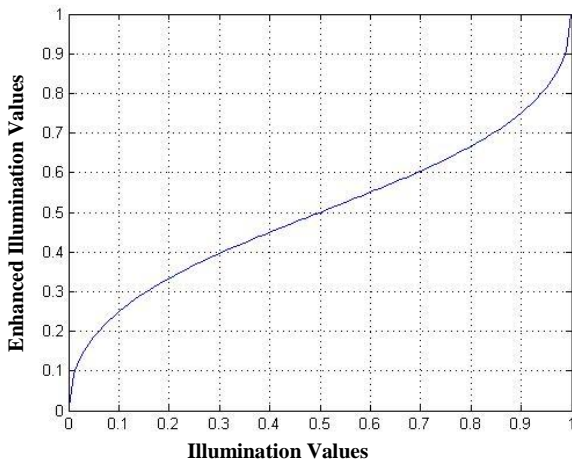

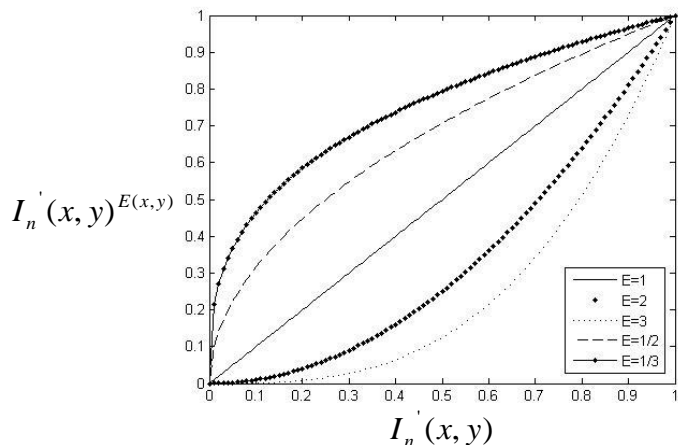**Figure (1) A set curve of transfer function.**

Figure (2) Intensity transformation for contrast enhancement.

contrast enhancement: is done by Center-surround contrast enhancement by using :

$$R(x,y) = 255 I'_n(x,y)^{E(x,y)} \qquad (17)$$

$$E(x,y) = \left(\frac{I_c(x,y)}{I(x,y)}\right) \qquad (18)$$

If the center pixel's intensity is higher than the average intensity of surrounding pixels, the corresponding pixel on the intensity-enhanced image will be pulled up, otherwise it will be pulled down. In fact, this process is an intensity transformation process. Considering the enhanced-intensity pixels are in the range (0 1)

color restoration: a linear color restoration process based on the chromatic information of the original image is applied to converting the enhanced intensity

image to RGB color image .The (r',g',b') of the restored color image are obtained by [7]:

$$r' = \frac{I'}{I} r \quad , \quad g' = \frac{I'}{I} g \quad , \quad b' = \frac{I'}{I} b \tag{19}$$

Finally, for optimal results of image enhancement contrast enhancement with multiple convolution results from different scales this inspiration from retinex algorithm [1]

$$R(x, y) = \sum_i w_i R_i(x, y) \tag{20}$$

Where i=1,2,3,… represent different scales (c_i) and w_i is the weight factor for each constant enhancement . The scales used in this search are 5,20 and 240 and w=1/3[7].

5. Result and discussion

In this work we captured two images from (Sony digital camera) with size (320×240) bmp type, one with low lightness (night image) and another with high lightness (fair or original image) as shown in figure(3-a & b)respectively . Original image is used to compare with processing image by calculated normalized mean square error NMSE that given by[8]:

$$NMSE = \frac{1}{N \times M} \sum_{x=1}^{N} \sum_{y=1}^{M} (\frac{Io(x, y) - Ip(x, y)}{255})^2 \tag{21}$$

Where *Io* being the lightness of fair image captured with preparation lightness its size (*N×M*) and *Ip* is the lightness of processing image resulted from HE, MSR algorithm and NAL algorithm. From figure (3-e) we noted in NLA enhanced image is more obvious however, increased contrast and lightness and distribution of its histogram nears from histogram of fair image, whereas in figure (3-c & d) the image enhanced by MSR algorithm is appeared best from that image enhanced by HE method because the fluctuation of its histogram.

The distribution of histogram in processing images reflected in NMSE as shown in table (1) appeared from these values the minimum value in image enhanced by NAL algorithm and gradually increasing in MSR algorithm and HE method.

6. Conclusion

The NAL algorithm is efficiently method to enhance low lightness images or night images compared with MSR algorithm and HE. This algorithm is restored many features that loosed in night image because low illumination however is increase the lightness and contrast in night image.
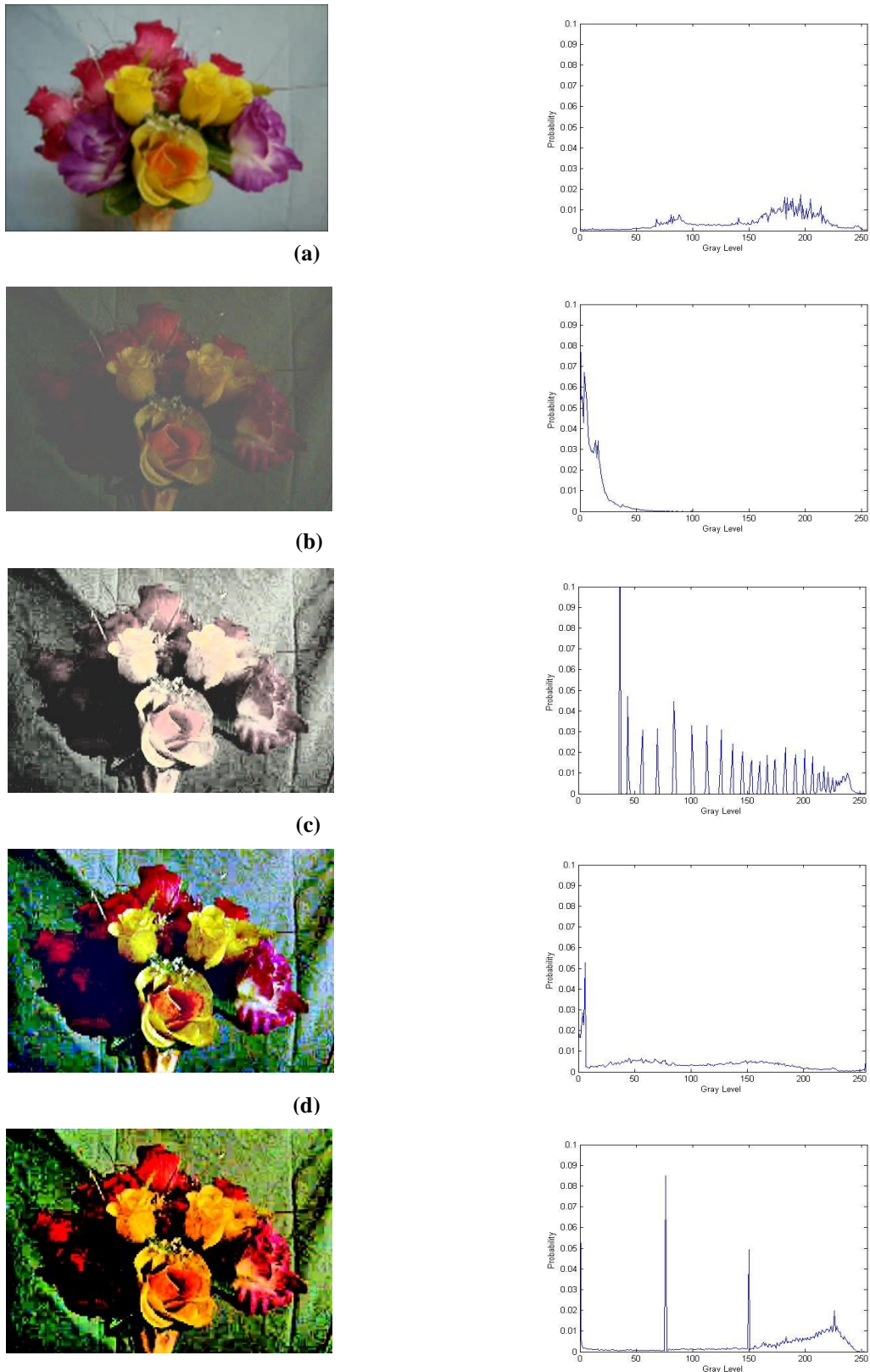
(a)

(b)

(c)

(d)

Figure (3) Left column represent :
 (a) original images. (b) night image (c) image enhanced with HE.
 (d) image enhanced with MSR algorithm. (e) image enhanced with NLA algorithm.
 right column represent : histogram of (a), (b) ,(c),(d) and (e) images.

Table 1: NMSE values for night image and enhanced images resulted from HE , MSR algorithm and NAL algorithm .

Image	night	HE	MSR	NAL
NMSE	0.3801	0.1740	0.1640	0.1421

1. D. J. Jabson, Z.Rahman, and G.A. Woodell, "A multi-scale retinex for bridging the gap between color images and the human observation of scenes," IEEE Trans. Image Process. 6, pp. 965-976, July (1997).

2. E.Land and J.Mc.Cann, "Lightness and retinex theory," J.Opt.Soc.Am, pp.61, (1971).

3.D. J. Jobson, Z. Rahman, and G. A. Woodell, "Properties and Performance of a Center/Surround Retinex," IEEE Transactions onImage Processing, March (1997).

4.Z. Rahman, D. J. Jobson, and G. A. Woodell, "A Multiscale Retinex for Colour Rendition and Dynamic Range Compression", SPIEInternational Symposium on Optical Science, Engineering and Instrumentation, Applications of Digital Image Processing XIX,Proceedings SPIE 2825, Andrew G. Tescher, ed., (1996).

5.Barnard, K. and Funt, B., "Analysis and Improvement of Multi-Scale Retinex," Proc. Fifth IS&T Color Imaging Conference," Scottsdale (1997).

6.Rafael C. Gonzalez,"Digital Image Processing Using MATLAB", Prentice-Hal ,(2004).

7. Li Tao and K. Vijayan Asari, "An adaptive and integrated neighborhood dependent approach for nonlinear enhancement of color images," SPIE Journal of Electronic Imaging, vol. 14, no. 4, pp. 1.1-1.14, October (2005).

8. S.J. Sangwine and R. E.N. Horne" The color image processing Handbook", Chapman & Hall (1998).

تحسين الصور الليلية باستخدام خوارزمية مقترحة غير خطية

الملخص

في هذا البحث تم اقتراح خوارزمية تحسين جديدة استخدمت لتحسين الصورة الليلية او الصور ذات الاضاءة الخافتة جداً باستخدام طريقة الالتفاف الكاوسي وديناميكية ضغط المجال للشدة بالاعتماد على دالة غير خطية ،مما يكون خوارزمية مرنة وذات معاملات قليلة اضافة الى ذلك تحسن المناطق المظلمة في الصورة الرقمية عن طريق تحسين الاضاءة والتباين سميت الخورارزمية المقترحة غير الخطية. تمت مقارنة النتائج مع تسوية الهستوغرام وخوارزمية (Retinex)عن طريق حساب معدل مربع الخطأ العياري بين الصورة المحسنة ونفس الصورة في حالة الاضاءة العالية و كذلك قورنت المخططات التكرارية في جميع طرائق التحسين . اظهر المرشح المقترح كفاءة عالية في تحسين الصور الليلية ذات الاضاءة الخافتة بالمقارنة مع الاساليب الاخر .