Studying for the Enhancement Captured Images at Different Lightness Directions and Levels Distribution Based on Using Histogram Equalization Method

Anwar H.M. Al-Saleh*[1], Salema S.S. Zuheri[2], Ali A.D. Al-Zuky[3]
[1]Department of Computer Science, College of Science, University of Al- Mustansariya, Baghdad, Iraq
[2]Department of Clinical Laboratory Science, College of Pharmacy, University of Baghdad, Baghdad, Iraq
[3]Department of Physics, College of Sciences, University of Al- Mustansariya, Baghdad, Iraq

Abstract

In this research we study the effect of the light distribution on the quality of captured images under different amount of lightness conditions then enhancing the captured images by the imaging system using an adaptive histogram equalization method and Lee method depending on the space YIQ depending on lightness component where use the reverse of this space to the basic RGB color space, then corrected using the mathematical model based on human vision system. The results were analyzed and compute the quality of the enhancement images by using various statistical criteria based on the mean and standard deviation. Adaptive histogram equalization technique gives a high quality for the enhanced images for different lightness conditions.

دراسة عملية تحسين الصور الملتقطة تحت شروط إضاءة مختلفة في مستويات الشدة واتجاه التوزيع بالاعتماد على تقنية معادلة المخطط التكراري

أنوار حسن مهدي*[1]، سليمة سلطان سلمان[2]، علي عبد داود الزكي[3]
[1]قسم الحاسوب، كلية العلوم، الجامعة المستنصرية، بغداد، العراق، [2]فرع التحاليل المرضية، كلية الصيدلة، جامعة بغداد،، بغداد، العراق
[3]قسم الفيزياء، كلية العلوم، الجامعة المستنصرية، بغداد، العراق

الخلاصة

توجهنا في هذا البحث لدراسة تأثير توزيع الإضاءة على جودة الصور لملتقطة تحت شروط إضاءة مختلفة ومن ثم يتم تحسين الصور الملتقطة باستخدام تقنية معادلة المخطط التكراري وتقنية تحسين لي بالاعتماد على فضاء YIQ عن طريق معالجة مركبة الإضاءة فقط، إذ تم استخدام التحويل العكسي من هذا الفضاء إلى الفضاء الأساسي RGB ثم صححت الألوان باستخدام موديل رياضي يعتمد على نظام الرؤية للإنسان. تم تحليل النتائج وتقدير جودة التحسين باستخدام معايير إحصائية متعددة تعتمد على حساب المعدل والانحراف المعياري والتباين. أعطت تقنية معادلة المخطط التكراري كفاءة عالية في حالتي الإضاءة العالية والقليلة.

Introduction

Image contrast enhancement plays an essential role in digital image processing [1]. The objective of image enhancement technique is to improve the image quality so that the processed image is better than the original image for a specific application or set of objectives [2]. Image quality plays an important role in various image processing applications [3].

The quality of the images could be affected by several factors. One of the most important factors is the illumination, which could be natural or artificial. Any weak in this factor will lead to a weak images quality, which will need to be enhanced through one or several image enhancement correction [4]. To improve the image contrast, numerous enhancement techniques have been proposed. One of the conventional methods adopted is the Adaptive Histogram Equalization (AHE) technique[1]. This method is simple and efficient when comparing with other method. Adaptive Histogram equalization tries to distribute more central gray level, extensively[5]. There are many studies that focused on improving digital images from where to improve the contrast and image analysis to determined its quality, and the most important of these studies are:-

Eli PeLi (1990): proposed method for contrast enhancement dependent on the physical contrast of simple images such as sinusoidal gratings or a single patch of light on a uniform background which is well defined and agree with the perceived contrast [6].

D. J. Jobson et.al. (1996): introduced new algorithm to improve the brightness, contrast and sharpness of an image. It performs a non-linear spatial/spectral transform that provides simultaneous dynamic range compression, and in 1997 they compared this method with another enhancement technique such as histogram equalization homomorphic filtering [7].

B.V.Funt et.al. (1997): introduced investigations into Multi-Scale Retinex algorithm approach to image enhancement to explain the effect of the processing from a theoretical standpoint . In the same year they modified the multi-scale retinex approach to image enhancement so that the processing is more justified from a theoretical standpoint by suggested a new algorithm with fewer arbitrary parameters that is more flexible [8].

Ali J. Al Dalawy (2008): studied the TV-Satellite images of "Al-Hurra" channel broadcasted on Arabsat, Hotbird and Nilesat. These image were the same with respect to the type on the three satellites. Analyzing these images done statistically by finding the statistics distribution and studying the relations between the mean and the standard deviation of the color compound (RGB) and light component for the image as whole and for the extracted homogeneous regions. Also he studied the contrast of image edges depending on sobel operator in limiting the edges and studied the contrast as function for edge finding threshold [9].

Salema S. Salman(2009) studied the effect of different lighting operations in type and intensity on test images using different light sources (tungsten and fluorescent lamp) and studied the distribution homogeneity of light intensity for the line partitioned from the middle of white test image width and height and focused on the contrast ratio as a function for light intensity using a test image with one half white and the other half black [10].

Diana C. Gil et.al. (2011): They introduced contrast enhancement methods and Image quality is evaluated by means of objective metrics such as intensity contrast and brightness error, and by subjective assessment. Execution time is also measured. They found the technique based on histogram modification presents a better trade-off considering both aspects [11].

Statistical Digital Image Properties

There are several image properties can be calculated from image data, the most imported properties (mean μ, standard deviation σ of the image or image regions) [12].

1- The Mean (μ)

Image mean brightness is known as the mean brightness for the image elements and it determined from the following relationship [13]:-

$$\mu = \frac{1}{MN}\sum_{x=1}^{M}\sum_{x=1}^{N} I(x,y) \qquad \text{………(1)}$$

Or by the following equitation:-

$$\mu = \sum_{g=0}^{L-1} gP(g) \text{……(2)}$$

Where I(x,y) is the intensity for the element image M × N is the image size.

P(g) is the probability distribution density in image.

L is the numbers of density levels in image.

2- Standard Deviation (STD)

The standard deviation represent the mean of variations of the element values with respect to its mean and it determined from the following relationship [14]:-

$$\sigma = \frac{1}{MN}\sqrt{\sum_{x=1}^{M}\sum_{y=1}^{N}(I(x,y)-\mu)^2} \text{ ……(3)}$$

Or by the following equitation:-

$$F = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N} I^2(x,y) \qquad \text{……(4)}$$

$$\bar{I}^2 = \sum_{g=0}^{L-1} g^2 p(g) \qquad \text{……..(5)}$$

$$\sigma = \sqrt{\bar{I}^2 - \mu^2} \qquad \text{………..(6)}$$

This standard is an important criterion to determine the amount of detail in the image.

Lee Enhancement Algorithm

Is an algorithm to improve the visual quality of digital images captured under extremely low or uniform lightening conditions. That is composed of three main parts: adaptive luminance enhancement, contrast enhancement and color restoration, this algorithm can be discus as flowing [15]:

a. 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 values of RGB image can be obtained as [16]:

$$I(x,y) = 0.298r(x,y) + 0.587g(x,y) + 0.114b(x,y) \quad ...(7)$$

and the Normalization Intensity is:

$$I_n(x,y) = I(x,y)/255 \quad ....(8)$$

The image information according to human vision behavior can be simplified and formulated as [19]:

$$I(x,y) = L(x,y)R(x,y) \quad ....(9)$$

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. 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 [15]:

$$I_c(x,y) = L(x,y) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} I(m,n)\,F(m+x,n+y,c) \quad ....(10)$$

I_c is image convolution, The second step is adaptive dynamic range compression of luminance by using the transfer function I'_n by [15]:

$$I'_n = \frac{I_n^{(0.75z+0.25)} + 0.4(1-I_n)(1-z) + I_n^{(2-z)}}{2} \quad ..(11)$$

Where z is the image dependent parameter calculated by [19]:

$$z = \begin{cases} 0 & for \quad L \le 50 \\ \frac{L-50}{100} & for \quad 50 < L \le 100 \\ 1 & for \quad L > 150 \end{cases} \quad ....(12)$$

This can be achieved by the following steps:

1. Input color image C(n,m,i), i=1,2,3 (red, green, blue) components.
2. Transform color image C(n,m) from RGB space to YIQ space and estimated lightness component Y(n,m).
3. Normalized lightness component I(m,n)= Y(n,m)/255 .
4. Calculated Gaussian surrounds function $F(x,y,c_n) = k\,e^{\frac{-(x^2-y^2)}{c_n^2}}$ where k is normalization constant, c_n, n=3, {c1=5, c2=20, c3=240}.
5. Computed convolution image from $$I_c(x,y) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} I(m,n)\,F(m+x,n+y,c_n)$$
6. Calculated $$T_n = \frac{I_n^{0.24} + (1-I_n)0.5 + I_n^{2}}{2}$$
7. computed reflectance image from $R(x,y) = 255 I'_n(x,y)^{E(x,y)}$, $E(x,y) = \left(\frac{I_c(x,y)}{I(x,y)}\right)^p$,P=1
8. Output image result from component $r' = \frac{I'}{I}r$, $g' = \frac{I'}{I}g$, $b' = \frac{I'}{I}b$.

Adaptive Histogram Equalization (AHE) Algorithm

To enhance captured images under different lightness conditions from lighting system using Adaptive Histogram Equalization, this performed by using YIQ color space and improve only the luminance component. The technical steps as follows:-

The first step in this algorithm is transforming color image from basic RGB color space to YIQ color space, the forward transform is given by the following equations:

$$\left.\begin{aligned} Y &= 0.299r + 0.587g + 0.114b \\ I &= 0.596r - 0.270g - 0.322b \\ Q &= 0.211r - 0.253g + 0.312b \end{aligned}\right\} \quad ...(13)$$

Where Y represent lightness component, and I,Q color component.

In the second step is transforming normalized lightness value using sigmoid function that is given by:

$$Y_n = \frac{1}{1 + \sqrt{\frac{1-I_n}{I_n}}} \quad ...(14)$$

Where I_n , Y_n are represented the internal and external lighting functions respectively, using Histogram Equalization technique.

The third step is applying HE on modify lightness component, the processing lightness component Y_n has been gotten form this step. Finally inverse transformation from YIQ to RGB color space calculated in YpIQ that is given by [51]:

$$\left.\begin{aligned} r &= y + 0.956i + 0.621q \\ g &= y - 0.272i - 0.647q \\ b &= y - 1.106i + 1.703q \end{aligned}\right\} \quad \dots\dots (15)$$

This can be achieved by the following steps:

1. Input color image C(n,m,i), i=1,2,3 (red, green, blue) components.
2. Transform color image C(n,m) from RGB space to YIQ space and estimated lightness component Y_n.
3. Normalized Y_n component by:

$$I_n = Y_n/25.$$

4. Transformed lightness component by using:

$$Y_n = \frac{1}{1 + \sqrt{\frac{1 - I_n}{I_n}}}$$

5. Applied HE on transformed lightness component I_n getting processed lightness component y_n.
6. Transform color image from Y_nIQ to get out put image.

Results and Discussion

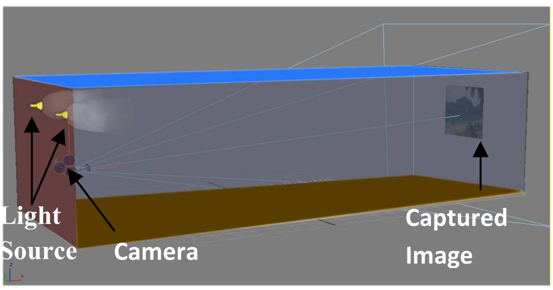


Figure 1- The Lighting System

Figure (1) shows lighting system, which consists of a dark box containing in one of its sides the light source (lamp from the right another from the left) to get a regular and irregular lighting. At the same side in the bottom of the lighting source there is a hole to put the camera. On the other side is placed the image to be captured under different lighting conditions.

All images in this study are taken by Sony Digital Camera, these captured images are of the (JPEG) format and with different intensities lighting depending on the voltage hanging on the light source. We capture 11 images, using a homogeneous lighting with different cases lighting, figures (2) shows the resulting images for different cases of lighting before applying enhancement methods, and figures(3,4) show the result images after using the Lee enhancement method, and AHE method respectively.

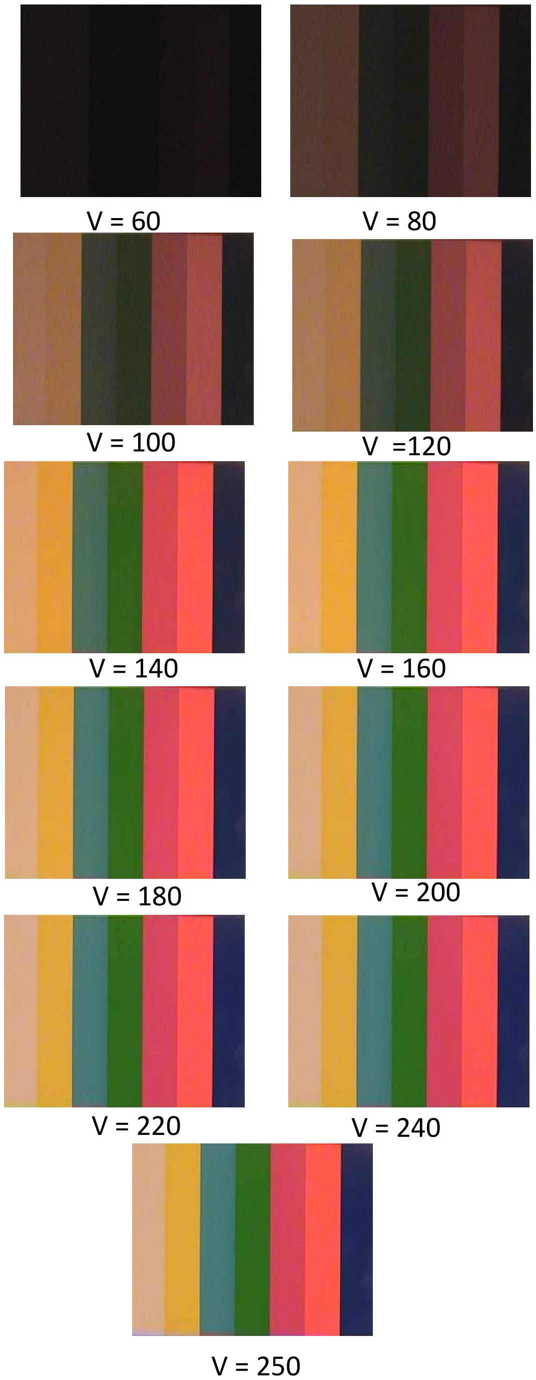


Figure 2- The Origin Images Before Using Enhancement Techniques.

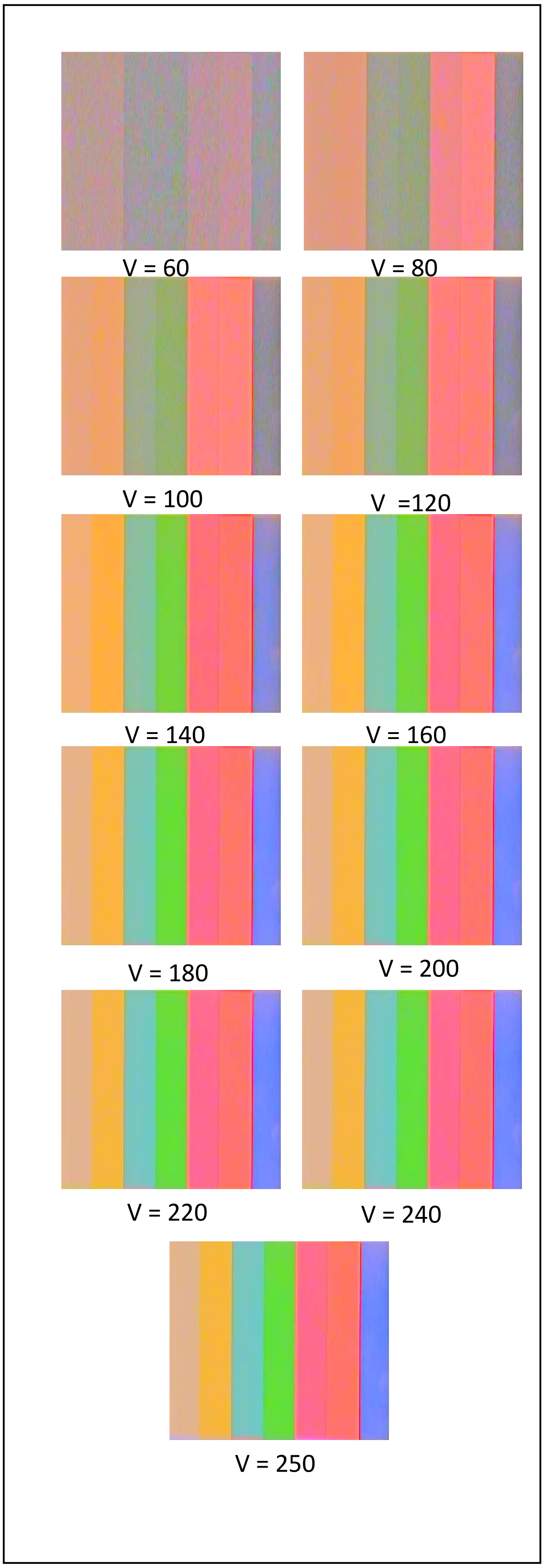


Figure 3- The Enhancement Images Using Lee Technique.

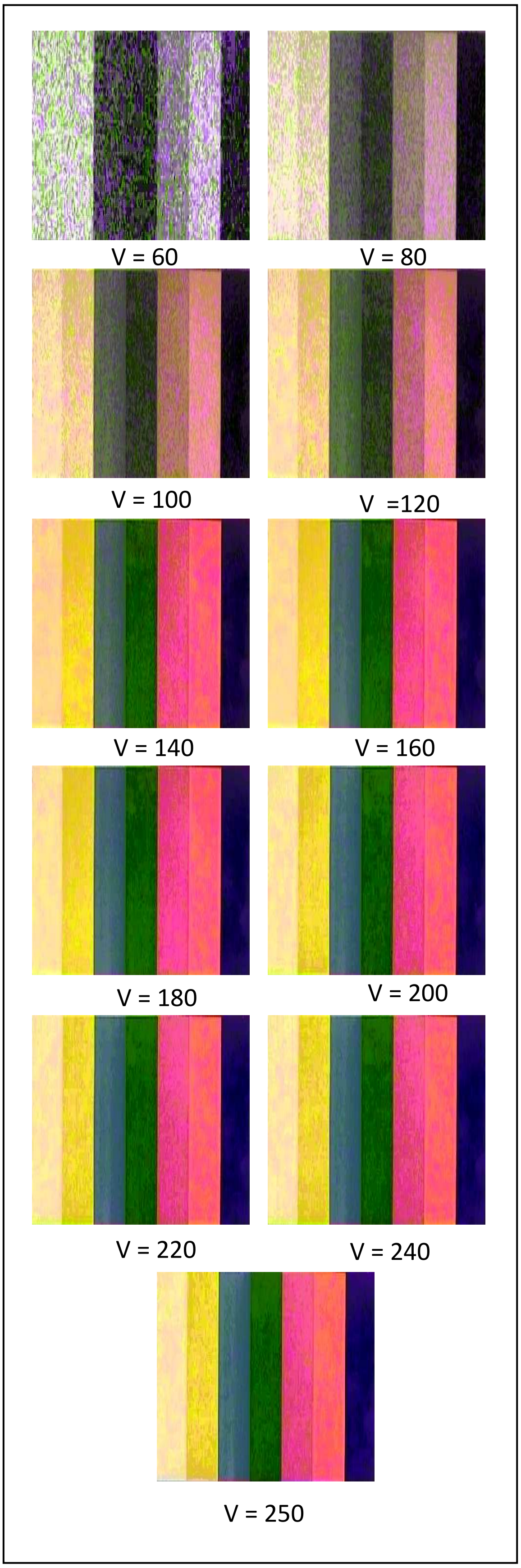
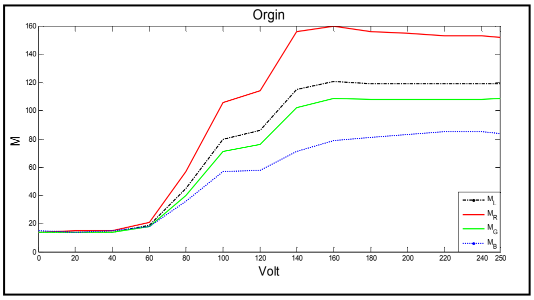
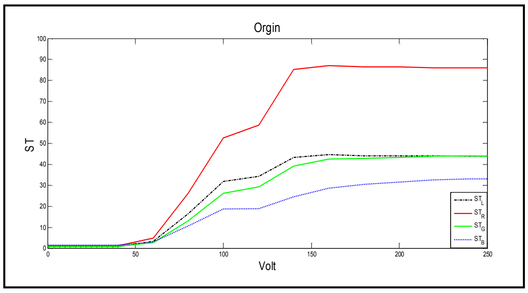


Figure 4- The Enhancement Images Using AHE Technique.

To assess the efficiency of techniques that is used in image enhancement in this study, by using different lighting, we calculate the statistical properties of images the mean (μ) and the standard deviation (STD), where the statistical properties were drawn as a function of voltage lighting system before and after the use of two enhancement methods, Lee method and AHE method. And the results shown in figurers (5,6,7).



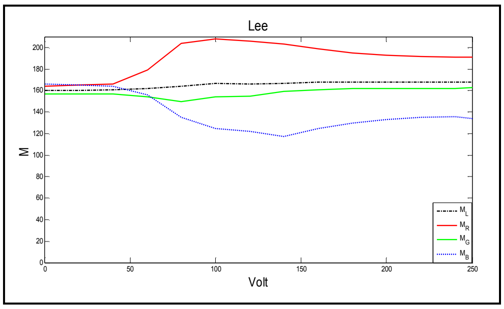
(a)



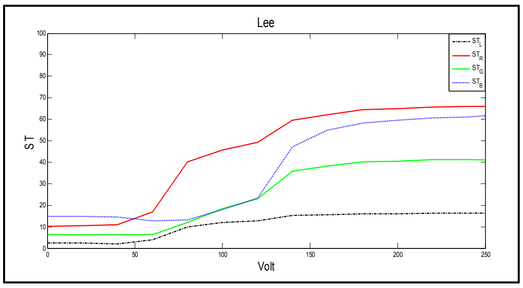
(b)

Figure 5- The Relationship Between (μ) And (STD) Of The Color Compound (RGB) And Light Component L For The Images As A Function Of Voltage Before Using The Enhancement Methods.

As clear from the figures the best image improve before enhancement methods in v = 140 volt, where the value of the overall contrast are higher in this case, and when increasing the voltage more, we note that the value of the contrast was decreased although increasing the light intensity. But after the enhancement process, we note that the contrast value almost equal for all enhanced images. As shown in figures (6,7).

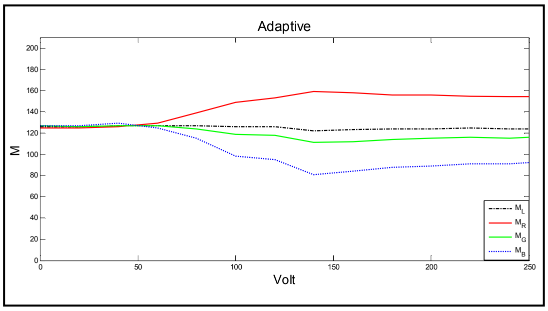


(a)

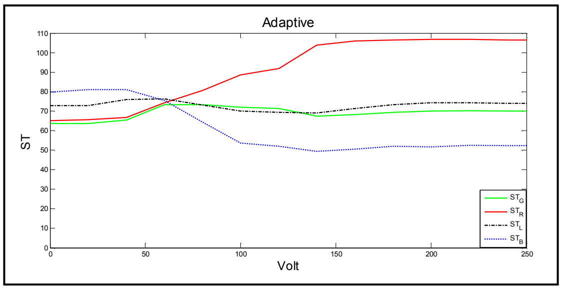


(b)

Figure 6- The Relationship Between (μ) And (STD) Of The Color Compound (RGB) And Light Component L For The Images As A Function Of Voltage After Using Lee Enhancement Method.



(a)



(b)

Figure 7- The Relationship Between (μ) And (STD) Of The Color Compound (RGB) And Light Component L For The Images As A Function Of Voltage After Using AHE Enhancement Method.

Conclusion

In this study, we improve the Lee and AHE enhancement methods based on the YIQ space by processing the lighting component only where the use of reverse conversion of this space to the basic space RGB colors and then corrected using the theory based on human vision system. The result show that the algorithm deal with images color with better results, and improves the image statistical properties (μ ,σ) for images enhancement are to maintain the general attributes of statistical properties of image with different lightings according the lighting intensity of imaging system .

References

[1] Sharmila R. and Uma R., **2011** "A New Approach To Image Contrast Enhancement using Weighted Threshold Histogram Equalization with Improved Switching Median Filter", International Journal of Advanced Engineering Sciences and Technologies Vol . 7, Issue no. 2,pp. 206 – 211.

[2] Jinshan T., Eli P., and Scott A., **2003**,"Image Enhancement Using a Contrast Measure in the Compressed Domain", IEE Signal Processing Letters, Vol. 10, no. 10.

[3] Bringier B., Richard N., Larabi M.-C. and Fernandez-Maloigne C., **2006** "No-Reference Perceptual quality Assessment of Colour Image", 14th European Signal Processing Conference (EUSIPCO 2006), Florence, Italy, pp. 4-8,.

[4] Ebrahim B. **2005**"Studying The Effect of Some Image Enhancement Features on The Accuracy of Close Range Photogrammetric Measurements Using CAD Environment", International Symposium, 26 September – 01 October, Torino, Italy.

[5] Phanthuna N., Cheevasuvit F. and Chitwong S. "Contrast Enhancement For Minimum Mean Brightnees Error From Histogram Partitioning".

[6] Eli Peli, **1990**, "Contrast in complex images", J. Opt. Am. A/Vol. 7, No. 10,.

[7] Jobson D. J., Rahman Z., and Woodell G. A., **1997** "A Comparison of the Multiscale Retinex With Other Image Enhancement Techniques ", Proceedings of the IS&T's 50th Annual Conference, Cambridge, MA,.

[8] Barnard K. and Fund B., **1997** "Analysis and Improvement of Multi-Scale Retinex" In Proceedings of the IS&T/SID Fifth Color Imaging Conference: Color Science, Systems and Applications, Scottsdale, pp. 221-226,.

[9] 9- Ali J. Al-Dalawy, **2008** "A Study of TV Images Quality for Channels Broadcast Television Satellite", Master of Science in physics Department, Al-Mustansiriya University.

[10] Salema S. Salman, **2009** " A Study Lighting Effect in Determining of Test Image Resolution", Ms.c thesis College of Science , Al-Mustansiriya University.

[11] Diana Gil, Rana Farah, J.M. Pierre Langlois, Guillaume-Alexandre Bi, Yvon Savaria2, **2011** "Comparative analysis of contrast enhancement algorithms in surveillance imaging", IEEE, ISCAS, pp. 849-852,.

[12] Ali A. al-Zuky, **2010** "Examining Contrast by Change of Lightness and Spatial Frequency", Al Mustansiryha J. Sci, V20,n6,pp.16-26.

[13] Ali A. al-Zuky, Salma S.S. Zuheri, and Kathem J. AL-Shujari, **2010** "Assessment Techniques for the contrast of Images have Different Illumination", Al Mustansiryha J. Sci. 21(6): 1-9.

[14] Hala N. Kadom, Ali A. al-Zuky, and Kathem J. AL-Shujari, **2010** "A Study on Nokia 7610 Cell-Phone Camera Statistics Properties in Different Lightness", Al Mustansiryha J. Sci., 21(6):38-46.

[15] Li Tao, Ming-Jung Seow and Vijayan K. Asari, **2006**," Nonlinear Image Enhancement to Improve Face ", International Journal of Computational Intelligence Research.ISSN 0973-1873 Vol.2, No.4, pp. 327-336 ,.

[16] Osman N. and Capt. Ender, **2007**," A non-linear Technique for The enhancement of extremely non-uniform lighting images ", journal of aeronautics and space technologies V. 3 No. 2 ,.

[17] Sony Wine S., J and Horne R.E., **1998** "The Color Image Processing Hand Book", International Thomson,.