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ENHANCEMENT OF THE CAPTURED IMAGES UNDER DIFFERENT LIGHTING CONDITIONS USING HISTOGRAM EQUALIZATION METHOD

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Abstract*- In this work we study the effect of the light distribution on the quality of captured images under different lightness conditions then enhancing the captured images using Histogram equalization 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 two statistical criteria the mean and standard deviation. Histogram equalization technique gives a high quality for the enhanced images for different lightness conditions.

Keywords - : Image processing ,histogram equalization, Image enhancement.

INTRODUCTION

Histogram processing is the act of altering an image by modifying its histogram. Common uses of histogram processing include normalization by which one makes the histogram of an image as flat as possible. In computer graphics, the process of improving the quality of a digitally stored image by manipulating the image with software. It is quite easy, for example, to make an image lighter or darker, or to increase or decrease contrast. Advanced image enhancement software also supports many filters for altering images in various ways. Programs specialized for image enhancement are sometimes called image editors Image enhancement is the process of adjusting digital images so that the results are more suitable for display or further image analysis. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. A very popular technique for contrast enhancement of images is Histogram Equalization (HE) (Gonzalez and Woods, 2008; Torre et al., 2005). HE is a technique commonly used for image contrast enhancement, since HE is computationally fast and simple to implement. HE performs its operation by remapping the gray levels of the image based on the probability distribution of the input gray levels[1].

IMAGE PROCESSING

Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers. The goal of this manipulation can be divided into three categories:

1- Image Processing
2- Image Analysis
3- Image Understanding

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Image processing is referred to processing of a 2D picture by a computer.An image defined in the "real world" is considered to be a function of two real variables, for example, a(x,y) with a as the amplitude (e.g. brightness) of the image at the real coordinate position (x,y) [2].

An image may be considered to contain sub-images sometimes referred to as regions-of-interest, ROIs, or simply regions. This concept reflects the fact that images frequently contain collections of objects each of which can be the basis for a region. In a sophisticated image processing system it should be possible to apply specific image processing operations to selected regions. Thus one part of an image (region) might be processed to suppress motion blur while another part might be processed to improve color rendition.The most requirements for image processing of images is that the images be available in digitized form, that is, arrays of finite length binary words. For digitization, the given Image is sampled on a discrete grid and each sample or pixel is quantized using a finite number of bits. The digitized image is processed by a computer. To display a digital image, it is first converted into analog signal, which is scanned onto a display [3].

PROCESSING TECHNIQUES

1- Image enhancement
2-Image restoration
3-Image compression etc.

Image enhancement:

It refers to accentuation, or sharpening, of image features such as boundaries, or contrast to make a graphic display more useful for display & analysis.

Image restoration:

It is concerned with filtering the observed image to minimize the effect of degradations. Effectiveness of image restoration depends on the extent and accuracy of the knowledge of degradation process as well as on filter design.

Image compression:

It is concerned with minimizing the no of bits required to represent an image [4].

IMAGE ENHANCEMENT

Image enhancement is one of the challenging issues in low level image processing. Contrast enhancement techniques are used for improving visual quality of low contrast images. Histogram Equalization method is one such technique used for contrast enhancement. And it a mean of the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image, Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine[5]. Histogram based image enhancement technique is mainly based on equalizing the histogram of the image and increasing the dynamic range corresponding to the image. Histogram Equalization is widely used in different ways to perform contrast enhancement in images, Image enhancement is the process of applying these techniques to facilitate the development of a solution to a computer imaging problem. Consequently, the enhancement methods are application specific and are often developed empirically[3]. The type of techniques includes point operations, where each pixel is modified according to a particular equation that is not dependent on other pixel values; mask operations, where each pixel is modified according to the values of the pixel's neighbors (using convolution masks); or global operations, where all the pixel values in the image (or sub image) are taken into consideration. Spatial domain processing methods include all three types, but frequency domain operations, by nature of the frequency (and sequence) transforms, are global operations.The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques [3, 4].

Image enhancement techniques can be divided into two broad categories:

1. Spatial domain methods, which operate directly on pixels, and

2. Frequency domain methods, which operate on the Fourier transform of an image.

Unfortunately, there is no general theory for determining what is `good' image enhancement when it comes to human perception. If it looks good, it is good! However, when image enhancement techniques are used as pre-processing tools for other image processing techniques, then quantitative measures can determine which techniques are most appropriate [6].

HISTOGRAM EQUALIZATION

This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images, and to better detail in photographs that are over or under-exposed. A key advantage of the method is that it is a fairly straightforward technique and an invertibleoperator. So in theory, if the histogram equalization function is known, then the original histogram can be recovered [7].

The calculation is not computationally intensive. A disadvantage of the method is that it is indiscriminate. It may increase the contrast of background noise, while decreasing the usable signal.In scientific imaging where spatial correlation is more important than intensity of signal (such as separating DNA fragments of quantized length), the small signal to noise ratio usually hampers visual detection.Histogram equalization often produces unrealistic effects in photographs; however it is very useful for scientific images like thermal, satellite or x-ray images, often the same class of images that user would apply false-color to. Also histogram equalization can produce undesirable effects (like visible image gradient) when applied to images with low color depth. For example, if applied to 8-bit image displayed with 8-bit gray-scale palette it will further reduce color depth (number of unique shades of gray) of the image. Histogram equalization will work the best when applied to images with much higher color depth than palette size, like continuous data or 16-bit gray-scale images [8] .

There are two ways to think about and implement histogram equalization, either as image change or as palette change. The operation can be expressed as P(M(I)) where I is the original image, M is histogram equalization mapping operation and P is a palette. If we define a new palette as P'=P(M) and leave image I unchanged then histogram equalization is implemented as palette change. On the other hand if palette P remains unchanged and image is modified to I'=M(I) then the implementation is by image change. In most cases palette change is better as it preserves the original data.Generalizations of this method use multiple histograms to emphasize local contrast, rather than overall contrast. Examples of such methods include adaptive histogram equalization and contrast limiting adaptive histogram equalization or CLAHE.Histogram equalization also seems to be used in biological neural networks so as to maximize the output firing rate of the neuron as a function of the input statistics. This has been proved in particular in the flyretina.Histogram equalization is a specific case of the more general class of histogram remapping methods. These methods seek to adjust the image to make it easier to analyze or improve visual quality (e.g., retinex)[9].

If lightness levels are continuous quantities normalized to the range [0, 1], pr(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[10],

$$s = T(r) = \int_0^r p_r(w)dw \ , \quad 0 \le r \le 1 \text{ ---------} \qquad (1)$$

Where w is a dummy variable of integration, that the probability density function of the output levels is uniform, that is[11]:

$$P_s(s) = \begin{cases} 1 & for\ 0 \le s \le 1 \\ 0 & else \end{cases} \qquad \text{-----------} \qquad (2)$$

When dealing with discrete quantities we work with histograms and call the preceding technique histogram equalization, where [12]

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

where: rk is normalized intensity level of the input image corresponding to the (un-normalized) intensity level k , $r_k = \frac{k}{L}$ (rk=0..1) and (k =0..L) and L =255 for lightness band with 8 bit/pixel), sk corresponding normalized intensity level of the output image .The cumulative probability density function (CPDF) calculated by[11,12]:

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

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

$$r_j = \frac{j}{L} \quad , j = 0..L. \qquad \text{------} \qquad (5)$$

wherenj being the number of pixel with intensity j and n is the total number of pixel of the image

EXPERIMENTALWORK

The algorithm which used in paper is:

1. Input color image *C(n,m)*.
2. Transform color image *C(n,m)* from *RGB* space to *YIQ* space and estimated lightness component *Y(n,m)*.
3. normalized lightness component $r_j = Y(n,m)/255$ and calculated iteration of each gray level n_j , where $j=0,1,..255$.
4. Computed histogram from $P(r_j)=n_j/N$, where *N* being the size of image.
5. calculated cumulative histogram by :

$$s_k = \sum_{j=0}^{k} \frac{n_j}{N} \text{ where} k=0,1,..255 .$$

6. Replaced each normalized component $r_j$by value of s_k and we get processing lightness component $Y_p(n,m)$.

Transform image from Y_pIQ to *RGB* color space.

Histogram Equalization Algorithm

RESULT AND DISCUSSION

The input images are shown in figure below:

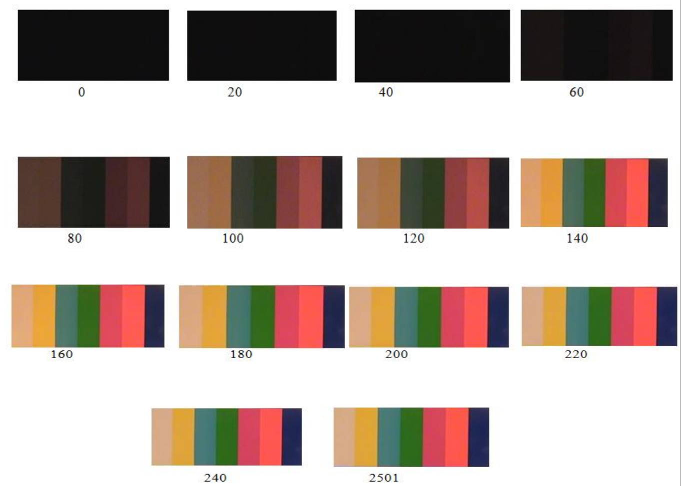

Figure 1- captured images under different lightness condition

The output images after applying algorithm of enhancement are shown in figure below

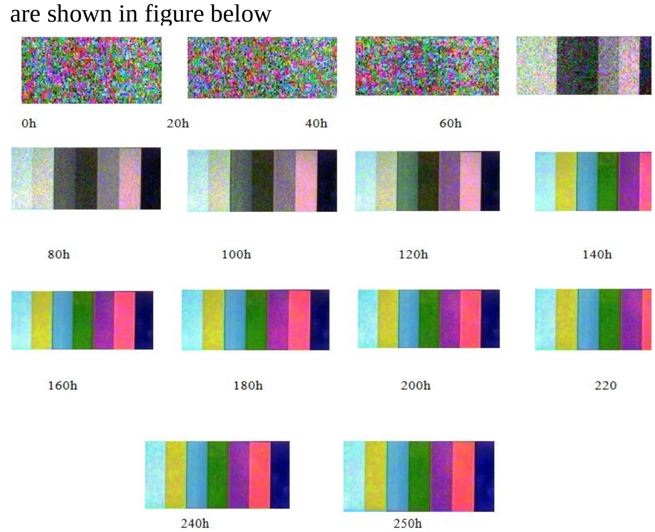

Figure 2- the output Images afterapplying algorithm

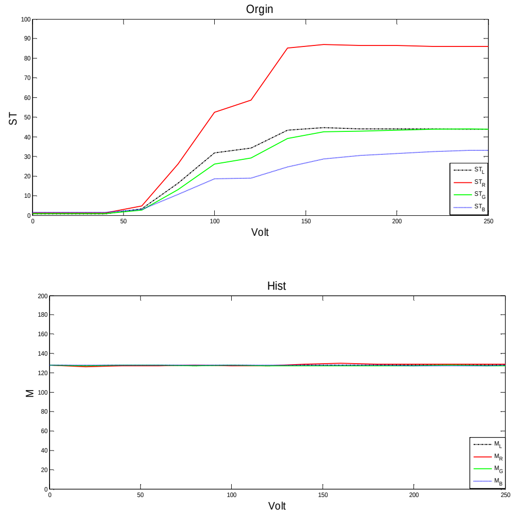

Figure 3 : The relationship between (μ) and (STD) of the color compound (RGB) and light component L for the images as a function of voltage before using the enhancement methods.

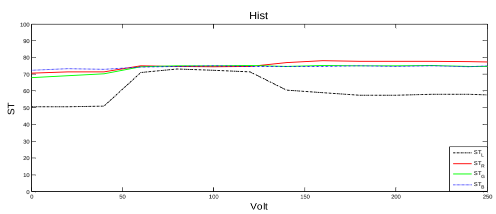

Figure 4 :The relationship between (μ) and (STD) of the color compound (RGB) and light component L for the images as a function of voltage after using HE enhancement method.

Conclusion

In this study, we improve the HE 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 .

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