Histogram Equalization for Standard Images

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Abstract: ***Histogram is the basis for numerous spatial domain processing techniques. Histogram manipulation is used for image enhancement. Histogram are simple technique to calculate in software and also lend themselves to economic hardware implementations, thus can be used as popular tool for real-time image processing. The focus of this paper is attempt to improve the quality of digital images using Histogram Equalization in MATLAB version R2007a software and result obtained are discussed and highlights the performance of method.***

Keywords: Image Enhancement, Histogram Equalization, MATLAB.

1. Introduction

Image Enhancement is the process of manipulating an image so that the result is more suitable than the original for a specific application. Digital image processing is an ever expanding and dynamic area with application into our everyday life. Image processing basically includes analysis manipulations, storage and display of the graphical images from source such as photographs, drawing and so on. Image enhancement basically includes noise reduction from image [2]. Image enhancement is one of the basic requirements for making an image useful for various statistical analysis and practical identification that from basis of various test and measurements in digital photography and much more digital imaging applications [2].

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing better input for other automated image processing techniques. The principal objective of image enhancement is to modify attribute of image to make it more suitable for a given task. During this process, one or more attributes of image are modified. The choice of attributes and the way they are modified are specific to given task. Image enhancement is used in following cases: Removal of noise from image, enhancement of dark image and highlighting the edges of the object in an image [3].The goal of image enhancement to improve the image quality so that the processed image is better than the original image for specific application [3].

2. Image Histogram

In general, a histogram is the estimation of the probability distribution of a particular type of data. An image of histogram offers a graphical representation of total distribution of the grey values in a digital image. By viewing the image's histogram, it can analyze the frequency of appearance of different grey levels contained in the image [4].

The *histogram* of a digital image with intensity levels in the range [0, *L* – 1] is a discrete function *h (rk*) = *n k,* where *r* k is the *k*th intensity value and n k is the number of pixels in the image with intensity of *r* k [1]. It is common practice to normalize a histogram by dividing each of its components by the total number of pixels in the image, denoted by the product *MN,* where, as usual, *M* and *N* are the row and column dimensions of the image. Thus, a normalized histogram is given by *p(r* k*) = n k /MN,* for *K = 0,1,2,……, L* – 1. Loosely speaking, *p(r* k*)* is an estimate of the probability of occurrence of intensity level *r* k in an image [1]. The sum of all components of a normalized histogram is equal to 1.

In histogram equalization technique, it is the probability density function (pdf) that is being manipulated. To make it simple, what histogram equalization technique does is that, it changes the pdf of a given image into that of a uniform pdf that spreads out from the lowest pixel value (0 in this case) to the highest pixel value (L – 1). This can be achieved quite easily if the pdf is a continuous function. However, since we are dealing with a digital image, the pdf will be a discrete function. Let's suppose we have an image x, and let the dynamic range for the intensity rk varies from 0 (black) to L – 1 (white). This pdf can be approximated using the probability based on the histogram *p(r* k*)* as follows [1]:

$$\mathrm{pdf}(x) = p(r_k) = \frac{\text{total pixels with intensity } r_k}{\text{total pixels in image } x}$$

From this pdf, we can then obtain the cumulative density function (cdf) as follows [1]:

$$\mathrm{cdf}(x) = \sum_{k=0}^{L-1} p(r_k)$$

Where *p(r* k is the probability for pixel of intensity. The output of a pixel from the histogram equalization operation is then equal to the cdf of the image or mathematically [1].

$$p(s_k) = \sum_{k=0}^{L-1} p(r_k)$$

To get the value of the pixel, p (sk) needs to be multiplied by L – 1 and then round it to the nearest integer [1].

3. Histogram Equalization

In the dark image the components of the histogram are concentrated on the low side of the intensity scale. Similarly, the components of the histogram of the light image are biased towards the higher side of the scale. An image with low contrast has narrow histogram located typically towards the middle intensity scale.

Histogram equalization is used to enhance the contrast of the image; it spreads the intensity value over full range. Histogram equalization technique can't be used for images suffering from non-uniform illumination in their backgrounds as this process only adds extra pixels to the light regions of the image and removes extra pixels from dark regions of the image resulting in high dynamic range in output image [2]. The goal of histogram equalization is to spread out the contrast of a given image evenly throughout the entire available dynamic range.

4. Experimental Results and Discussion

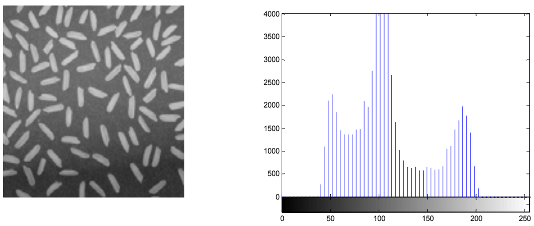

Figure 4.1 (a): Original Image with its histogram

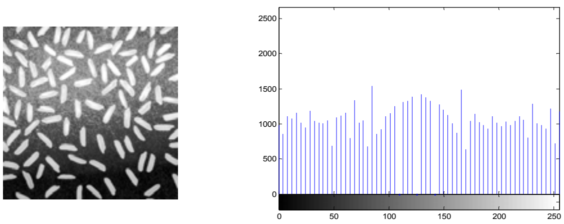

Figure 4.1 (b): Image after histogram Equalization and its Histogram

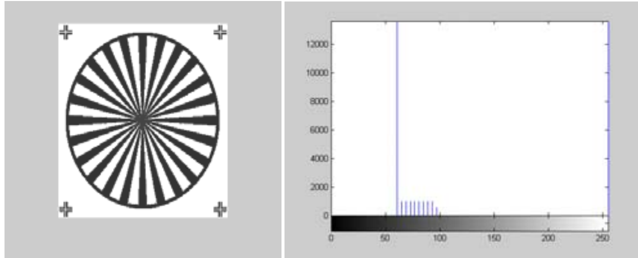

Figure 4.2 (a): Original Image with its histogram

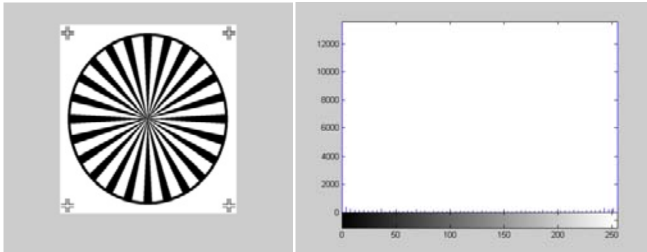

Figure 4.2 (b): Image after histogram Equalization and its Histogram

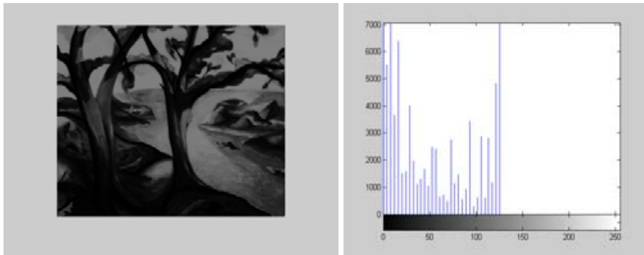

Figure 4.3 (a): Original Image with its histogram

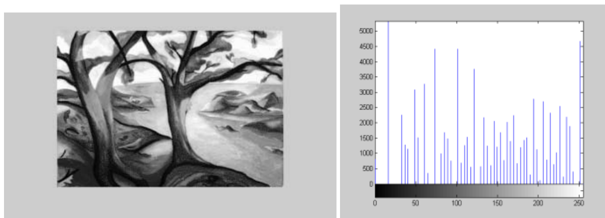

Figure 4.3 (b): Image after histogram Equalization and its Histogram

Histogram of equalized images are shown in figure 4.1(b), 4.2(b) and 4.3(b) and they are different but histogram equalized images are visually very similar i.e. improved. This is not unexpected because the basic difference between images in figure 4.1(a), 4.2(a) and 4.3(a) of contrast.

In other words, images have same content the increase in contrast resulting from histogram equalization is enough to render any intensity difference in the equalized image which is visually improved. Given the significant contrast differences between original image and equalized image, experiment illustrates power of histogram equalization as an adaptive contrast enhancement tool.

5. Conclusion

This paper made an attempt to study Image Enhancement by Histogram Equalization. The performance of these techniques was carried out with three images using MATLAB version R2007a .Histogram Equalization was carried out on the images. It was observed from the result of histogram equalization, a high contrast was achieved for the image making the intensity values spread over a full range. Experiment illustrates power of histogram equalization as an adaptive contrast enhancement tool.

6. Acknowledgments

Special thank and recognition go to our advisor, Prof. Janardan Pawar ,Vice Principal, ICCS who guided us through this research, inspired and motivated us. Last but not least, we would like to thank the Indira College of Commerce and Science (ICCS), Pune, India for supporting this research study.

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