ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 8(29), DOI: 10.17485/ijst/2015/v8i29/83974, November 2015* ISSN (Online) : 0974-5645

Color Image Enhancement using Edge Based Histogram Equalization

N. Anjana*, J. Jezebel Priestley, V. Nandhini and V. Elamaran

Department of Electronics and Communication Engineering, School of EEE, SASTRA University, Thanjavaur – 613401, Tamil Nadu, India; anjananatarajan41@gmail.com, jzpriestley@gmail.com, nandi2192@gmail.com, elamaran@ece.sastra.edu

Abstract

Image enhancement is one of the major research areas in the field of digital image processing. The sole objective of this domain is to enhance the quality of a poor contrast image. As a result, the final processed image becomes much more understandable than the original one. A new edge based histogram equalization method is proposed in this study. A high pass filter is used to detect edges with a help of an appropriate gradient operator. In general, a convolution mask is used for this kind of area processes like filtering. This proposed method increases the quality of the poor contrast area. This method does not create an impact on brighter area in the given input image. A few portion of the poor contrast is raised and few others contrast are being reduced. The simulation results of this study are compared with the conventional histogram equalization. Our experimental results show that the Peak Signal-to-Noise Ratio (PSNR) is better than the regular Histogram Equalization (HE) method. All simulation results are obtained using Matlab simulation software tool with standard color test images. Color image enhancement methods are applicable in the areas such as iris recognition, digital photography, remote sensing, biology, medicine, geophysics and microarray techniques, etc.

Keywords: Contrast Enhancement, Edge Detection, Histogram Equalization, Image Enhancement, PSNR

1. Introduction

In the current digital world trend, digital image processing is one of the major concern in the field of computer science. If the information is lost or poor in contrast in an image, pictorial information is improved through image processing which is essential for human perception and also for machine vision applications. The other most popular applications of digital image processing are image restoration, image analysis, image compression, image understanding and pattern recognition[1].

In low level image processing, image enhancement is the fundamental issue and the most relevant for further high level processing. If the original image contain loss in information which is not suitable for any kind of applications, image enhancement method would enrich the quality of the low contrast image. The applications of the image enhancement are abundant like medical image analysis, preprocessing steps for face recognition, photograph restoration, remote sensing, etc. The most easy and fundamental technique for enhancing the low contrast pixels is the histogram equalization[2]. The concept behind this histogram equalization is distributing the pixel count uniformly to some extent equally. These kind of algorithms used for increasing the low contrast pixel are computationally efficient[3]. HE methods are specifically used for improving the global contrast of images when the most important information is presented by close contrast values. The shifting the mean of the brightness of the image is also being referred to as histogram equalization. Obviously the irrelevant visual artifacts cannot omitted pixels because of the brightness changes[4,5].

The most frequent pixel intensity values are distributed in the histogram technique. The final distributed histogram would act as the transfer mapping function while transforming the input image to the resultant image. The adjustment of the local contrast of the given image cannot be done effectively using the HE method

** Author for correspondence*

which becomes a drawback[6]. Edge detection is an another important application in the image enhancement context and especially useful for the applications like computer vision, machine learning, human computer interaction and pattern recognition. To enhance the quality of the edges in an image, the significant feature from the edge is extracted effectively using the appropriate gradient operators[7,8].

This paper is organized as follows. Section II describes about histogram equalization transformation function and its alteration for the color images. Section III presents how edge detection plays an important role in histogram equalization. Then experimental results are compared with few test images along with the PSNR are discussed in section IV. Finally in section V, the conclusion is presented.

2. Histogram Equalisation For Color Image

2.1 Convential Histogram Equalization

The main objective of the HE method is to distribute the pixel contrast uniformly for the given image in the range between 0 to 1. The actual Probability Density Function (PDF) is get modified. The final one becomes the uniform PDF in which histogram equalization is to spread out contrast of a given image uniformly throughout the entire available dynamic range between 0 to 1. In histogram equalization, the probability density function (PDF) is being manipulated and becomes a uniform one. Here all the pixel intensity values from low to high are modified[10,11].

This process would be done easily if the PDF is a continuous function. But in the digital imaging world, the PDF is a discrete function due to the discrete nature of the digital image. For the given original input image I and the intensity dynamic range varies from I_0 to I_{L-1}, the PDF is given by[9],

$$prob(i) = \frac{n_i}{N} \quad for\ i = 0,1\&.., L-1 \tag{1}$$

Where the total number of pixels is N and n_i is the frequency of occurrence of the intensity *i* in the input image[9,12].

To achieve the task of the HE method, the transformation function $T_i(x)$ which map the input mage to the overall entire dynamic range and is given by[9], In histogram equalization, the transformation function $T_1(x)$ which map the given image into the entire dynamic range of and it is given by[9]

$$T_1(x) = I_0 + (I_{L-1} - I_0)\sum_{k=I_0}^{x} p(k) \tag{2}$$

The equation (2) is implemented to transform the input image is which shown in Figure 1 (a). The resultant image is shown in Figure 1 (b) by the conventional HE method. Figure 1 (c) and (d) shows the histogram of the luminance component of input image and histogram of the luminance component of the equalized image.

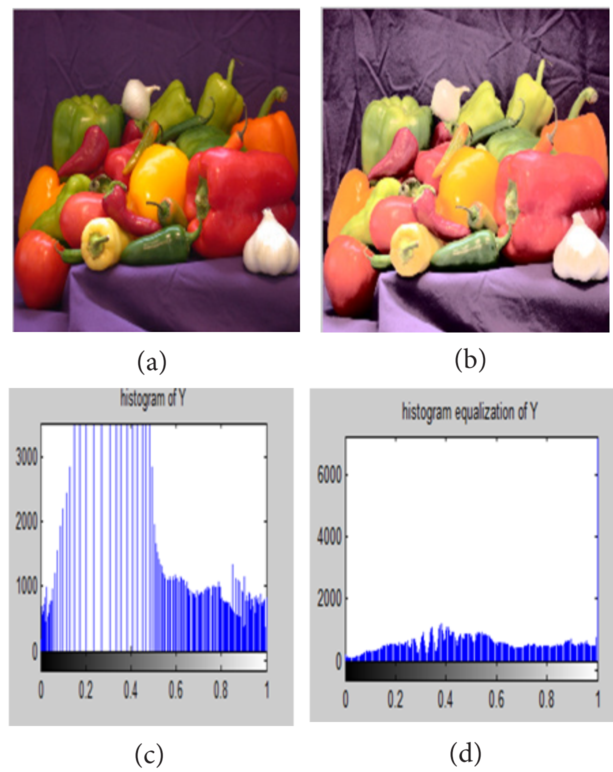
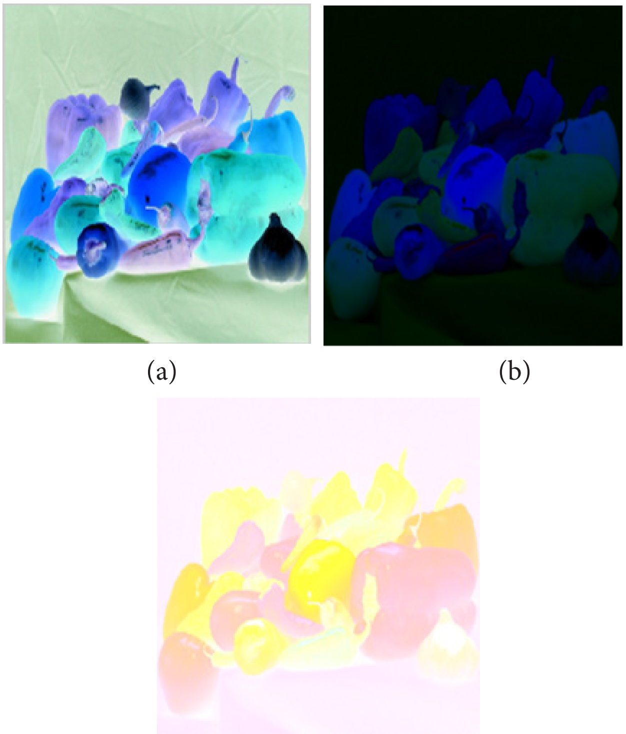


Figure 1. (a) Input image (b) Output image after HE process (c) Histogram of input image (d) Histogram of the equalized image.

The PDF is calculated for the image in which the pixel intensity values are reversed. The transformation $T_2(x)$ of this given negative image is obtained by the following equation[9],

$$T_2(x) = I_0 + (I_{L-1} - I_0)\left(1 - \sum_{k=x}^{I_{L-1}} p(k)\right) \tag{3}$$

The resultant image using the equation (3) is shown in Figure 2 (a). The quantization has been applied to the negative image and the result is shown in Figure 2 (b). The negative image of the quantized reverse image which is not similar to the equation (3).



(a) (b)

(c)

Figure 2. (a) Negative of the input image (b) Output image after HE process (c) Negative of the image 2.

2.2 Mean Histogram Equalization

The transfer functions are averaged and the new transfer function $T_3(x)$ is obtained from the equations (1) and (2)[9].

$$T_3\ (x) = I_0 + (I_{L-1} - I_0)\left(0.5p(i) + \sum_{k=I_0}^{x-1} p(k)\right) \quad (4)$$

Using this equation, the resultant image is shown in Figure 3 which is better than implemented image as in third equation.

Color Image consist of information which are rich than the grayscale images[7]. For equalizing the color image, first the color image is transformed from RGB value to YIQ value. Since the Y channel contain almost of the signal energy, it chosen for the equalization to improve the luminance. The I channel and Q channel contains only the color information, so it is not required for equalization. The Y channel is equalized by histogram equalization and repacked with the I and Q channel. Then YIQ values are transformed back into RGB values. The Y channel is equalized by the equation (2), equation (3) and equation (4) so that the three resultant images differ from each other[4].

(a) (b)

Figure 3. (a) Output image (b) Output image after equation (3) is processed (c) Negative of the image 2. (b)

3. Edge Based Histogram Equalization

The extraction of an important features of an image is the main objective of edge detection. The appropriate filters are used to improve the quality of the edges during the edge detection process. In general, the high pass filter would be the best choice for this edge detection. Sobel, Canny, Laplacian and Roberts convolution kernels are the mostly used techniques in the edge detection. A two-dimensional Sobel 3 x 3 or 5 x 5 convolution mask is being applied row-wise and column-wise to the given image to produce the final edge detected output image. Accordingly, the horizontal and vertical edges are obtained in order to produce the overall edge detection result[4].

The diagonal edges are more accurately retrieved by Sobel than other popular gradient operators[13]. Prewitt gradient operators are good for obtaining horizontal and vertical edges. All kind of results are obtained in Figure 4 and Figure 5 using various edge detection gradient operators. Edge detection algorithms are much useful in the medical image analysis, patter recognition, computer vision, machine learning, human-computer interaction, etc.

The brighter spots are not enhanced using these kind of algorithms. Histogram equalization with edge based approach would improve the contrast depends on the requirement. If the original pixels are not brighter,

Figure 4. (a) The input image of "Peppers". Edge based HE by (b) Horizontal Sobel (c) Vertical Sobel (d) Diagonal Sobel (e) Horizontal Prewitt (f) Vertical Prewitt (g) Diagonal Prewitt (h) Horizontal Roberts (i) Vertical Roberts (j) Laplacian.

they are enhanced and if they are poor in contrast, the improvement is made in contrast too. The noise content in the image may not be enhanced using this approach. The images in which more number of dark pixels are available, are used in this proposed method of edge based histogram equalization.

4. Simulation Results

The standard performance metrics like the MSE and PSNR are used to prove the edge based histogram equalization is better than the conventional histogram equalization. These are analyzed as follows with standard test images.

4.1 Mean Sqaure Error (MSE) and PSNR

The widely used performance metrics are Mean Square Error (MSE) and the Peak Signal-to-Ratio (PSNR) in the image processing field of research[4,10]. Let *f(i,j)* be the original image with size MxN and *f'(i,j)* the modified image with the same size. The MSE is expressed as:

$$MSE = \frac{1}{MN}\sum_{ij}(f'(i,j) - f(i,j))^2 \qquad (5)$$

and the PSNR in decibel is expressed as:

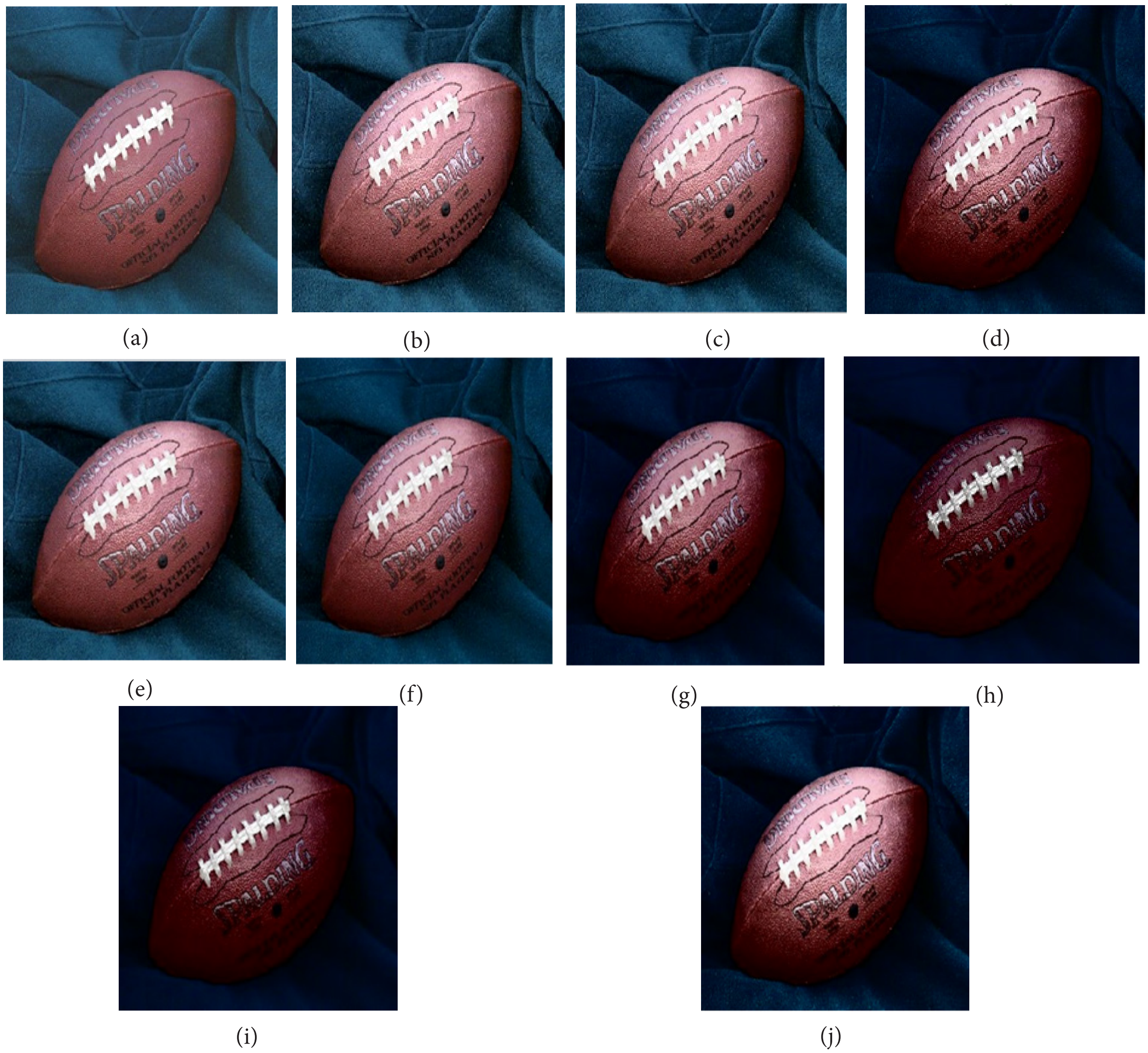


Figure 5. (a) The input image of "Football". Edge based HE by (b) Horizontal Sobel (c) Vertical Sobel (d) Diagonal Sobel (e) Horizontal Prewitt (f) Vertical Prewitt (g) Diagonal Prewitt (h) Horizontal Roberts (i) Vertical Roberts (j) Laplacian.

Table 1. PSNR results with standard histogram equalization and edge based histogram equalization

Test Images	Standard Histogram Equalization	Edge based Histogram Equalization
Onion	12.73	13.76
Football	11.34	12.58
Peppers	12.54	13.23
Board	12.49	13.11
Greens	6.86	6.98
Fabric	8.11	8.93
Hestain	13.06	13.91
Pears	10.40	11.33
Tissue	13.63	14.05

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{255\times255}{MSE}\right) \qquad (6)$$

The results with a comparison analysis are obtained in the Table 1. The PSNR results offered by the edge based histogram equalization method are better than the regular histogram equalization method.

5. Conclusion

The betterment of contrast details in the image is more important to analyze, understand and process the image further. This study conveys the edge based histogram equalization method to improve the contrast details. The regular histogram equalization method enhances the actual pixels and the noise content as well. This problem is avoided with the proposed method and the results are compared. This work can be further modified to adaptive histogram equalization with an edge based approach.

6. References

1. McKinley GA. An introduction to digital image processing. Clinical Microbiology Newsletter. 1990 Jun; 12(12):89–92.
2. Gonzalez RC, Woods RE. Digital Image Processing. Second edition. Prentice Hall of India New Delhi; 2002.
3. Cheng HD, Shi XJ. A simple and effective histogram equalization approach to image enhancement. Digital Image Processing. 2004 Mar; 14(2):158–70.
4. Li T. Digital signal processing: Fundamentals and applications. Academic Press; 2007.
5. Singh K, Kapoor R. Image enhancement using exposure based sub image histogram equalization. Pattern Recognition Letters. 2013 Sep; 36:10–4.
6. Willams B, Hung CC,Yen KK, Tucson AZ, Coleman T. Image enhancement using the modified cosine function and semi-histogram equalization for graysacle and color images. IEEE International Confernce on Systems, Man and Cybemetrics (ICSMC). 2001; 1:518–23.
7. Qu Z, Yantai, Shandong, Wang J. A color YUV image edge detection method based on histogram equalization transformation. International Conference on Natural Computation (ICNC). 2010; 7:3546–9.
8. Cheong CK, Aizawa K, Saito T, Hatori M. Structural edge detection based on fractal analysis for image compression. International Conference on Circuit and Systems (ISCAS 1992); San Dieogo, CA. 1992; 5:2461–4.
9. Ibrahim H, Kong NSP. Image sharpening using sub region histogram equalization. IEEE Transactions on Consumer Electronics. 2009 May; 55(2):891–5.
10. Kadhum ZA. Equalize the histogram equalization for image enhancement. Journal of Kufa for Mathematics and Computer. 2012 May; 1(5):14–21.
11. Marques O. Practical image and video processing using MATLAB. Wiley-IEEE Press; 2011.
12. Ooi CH, Isa NAM. Adaptive contrast enhancement methods with brightness preserving. IEEE Transactions on Consumer Electronics. 2010 Nov; 56(4):2543–51.
13. Crane R. A simplified approach to image processing. Prentice Hall PTR; 1997.