Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.6, No.2, 2016

Enhancement of Chest X-ray Images for Diagnosis Purposes

Salim J. Attia
Department of Basic Sciences, College of Dentistry, University of Baghdad

Abstract
This study presents image quality comparison between original images and three image enhancement techniques namely imadjust, histogram equalization (HE) and contrast limited adaptive histogram equalization (CLAHE). These techniques are applied to a collection of eight chest x-ray images which are considered as dark, noisy and low in contrast and radiation dosage. The lacks of quality can be solved with these enhancement image techniques. These techniques raised the quality of images and improve the diagnostic ability of the pathological features observed in the images. Then the quality image factors including peak signal-to-noise ratio (PSNR), Mean squared error (MSE), (MAXERR) and (L2rat) were used to evaluate the characteristic of the images. The findings showed that the enhancement techniques managed to enhance the images make them more qualified than original images.
Keywords: Histogram Equalization, Contrast Limited Adaptive Histogram Equalization and Image Quality.

1. Introduction

X-ray is the first line of diagnosis by imaging modalities; although other modalities such as Magnetic Resonance Imaging (MRI) and Computer Tomography (CT) give more accurate interpretations (Ozen et al. 2009). X-ray is used in many applications for different medical and industrial purposes, but its images are dark and low contrast. The digital image enhancement methods have become a major process for getting information from the images structure and make the interpretation of these images better. So, in this study we used three enhancement methods to improve x-ray image appearance and contrast.

Some of the x-ray images have real problem, because it was very dark, and don't have useful details; the increasing in brightness and contrast is very important purpose in the studies included these images.

Many studies have been undertaken to enhance the x-ray images for extracting information about the sample structure and make interpretation of these images easier and the diagnosis more accurate (Mehdizadeh and Dolatyar 2009, Rahmati et al. 2010, Al-Zuky et al. 2009, Uroukov et al. 2014).

2. Methology

Enhancement methods:

Imadjust converts the values in grayscale image I to new one as image J in which 1% of values are saturated at minimum and maximum intensities of I. This led to increase the contrast of the resulted image J (MATLAB R2012a):

$$J = imadjust(I, [low\ in; high\ in], [low\ out; highout], gamma) \quad (1)$$

When gamma is less than 1, the output image becomes brighter (higher values). When gamma is greater than 1, the output image becomes darker (lower values).

Histogram equalization (HE) is a technique enhances the contrast of images by which the range of the histogram is increased (Chen and Ramli 2003). It stretches the range of the image histogram; therefore, that the histogram of the output image nearly identifies a specified histogram and reflects a uniform distribution of intensities. The appearance of enhanced image is improved with HE algorithm by replacing each pixel a new intensity value according to previous intensity value by using following Equation (Sity et al. 2012):

$$G_i = \left\lfloor \sum_{j=0}^{i} N_j \right\rfloor \left(\frac{max\ Intensity\ Level}{No\ of\ Pixels} \right) \quad (2)$$

Contrast Limited Adapted Histogram equalization (CLAHE) is originated from histogram equalization (HE). It performs contrast-limited adaptive histogram equalization. Unlike Histogram Equalization, it works on limited data regions or tiles rather than the total image. Each region's contrast is enhanced so that the histograms of each input region and output result are approximately matched. If there is a noise in the image the contrast enhancement must be limited to avoid the amplification of noise (Zuiderveld 1994)

Image quality measures:

Mean Square Error (MSE)

The mean square error (MSE) has been the main quantitative performance metric in the field of image evaluation. It is the dominant criterion for the assessment of image quality. It is accumulative sum of square error between original and enhanced image. If the MSE value is lower, then the error is lower (Reka Durai and Thiagarasu 2014):

$$\mathrm{MSE} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[I(i,j) - J(i,j)]^{2} \qquad (3)$$

M and N are total number of pixels in the rows and columns of original and enhanced image (I &J).

Peak Signal to Noise Ratio (PSNR)

The PSNR represents the peak signal-to-noise ratio between two images. This ratio is used as a quality measure between the original and an enhanced image. If the PSNR is higher, the quality of enhanced image is better. PSNR included two metrics of error used for comparing the image enhanced quality. PSNR is a measure of the error of peak (Huynh 2008):

$$PSNR = 10\, log_{10}\left[\frac{R^2}{MSE}\right] \qquad (4)$$

R represents the maximum fluctuation of input image. It equals to 255 for 8-bit unsigned integer data type.

Maxerr

MAXERR is the maximum absolute squared error of the specified output data with a size equal to that of the input data (Huynh 2008).

L2Rat

It represents the ratio of the squared norm of the output image to the input image (Huynh 2008).

3. Results and Discussion

The enhancement techniques included Imadjust, HE and CLAHE are applied on X-ray chest images like those are in figure 1 to improve their appearance for diagnosis goal and the results are like those are in figures 2, 3 and 4. The histograms of original and 3 enhanced images which are resulted from the three techniques are shown in figures 5, 6, 7and 8. It is clear that the histograms match each other but there is difference in stretching and fill of each data as clearly in figures represented by (Imadjust, HE and CLAHE) techniques respectively. High contrasting is happened in the edges in all methods; it is highest in HE images but some details disappeared. CLAHE images relatively less contrast than HE but more details are obtained.

Table (1) represents the values of MSE, PSNR, MAXERR and L2Rat of all the images. The results showed much difference between MSE values in original images and those in enhanced images of all three techniques and the original images have bigger values than all enhanced images. In enhanced images themselves there is little difference in MSE values but the images that are resulted from CLAHE have lowest values in 6/8 cases. PSNR values in original images are lowest and the enhanced images of CLAHE technique have bigger values than other enhanced images in 5/8 cases. Basing on the fact that lowest value of MSE and the highest value of PSNR are the best; the images which are resulted from CLAHE technique have best quality. The values of MAXERR are unchanged while the L2Rat values are lowest in 7/8 cases in CLAHE results. Figure 9 showed the stacked line with contribution of each value over its category included the original images and the enhanced images with their quality measures values.

4. Conclusion

The study explained that all three enhancement methods give good appearance of the images especially in the images resulted from CLAHE technique. The images resulted from HE technique are more bright and CLAHE images are less bright compared with others but the detail of images are better in CLAHE images, so it is better for diagnostic purposes. Although the quality measures generally have close values, they are better in CLAHE technique than others.

References

Al-Zuky A. A. , Jawad H. H. and Al-Wahieb F.S. , (2009), "Hybrid Contrast Enhancement for X-ray Images", Al- Mustansiriya J. Sci., 20(1), 91-97.

Chen Soong-Der and Ramli Abd.Rahman, (2003), "Minimum Mean Brightness Error Bi-Histogram Eualization in Contrast Enhancement", IEEE Transactions on Consumer Electronics, 49(4), 1310-1319.

Huynh Thu, (2008), "Scope of validity of PSNR in image/video quality assessment", Electronics Letters, 44, 800–801.

MATLAB R2012a, The MathWork, Inc. http://www.mathworks.com/help/matlab.

Mehdizadeh M. and Dolatyar S. , (2009), "Study of Effect of Adaptive Histogram Equalization on Image Quality in Digital Periapical Image in Pre Apex Area", research Journal of Biological Science, 4(8), 922-924.

Ozen T. , Cebeci A. and Paksoy C. S. , (2009), "Interpretation of Chemically Created Periapical Lesion Using 2 Different Dental Cone-Beam Computerized Tomography Units, and Intraoral Digital Sensor, and Conventional Film", Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod, 107(3), 426-432.

Rahmati P. , Hamameh G., Nussbaum D. and Adler A. , (2010), " A New Preprocessing Filter for Digital Mammograms", Lecture Notes in Computer Science, 6134, 585-592.

Reka Durai and Thiagarasu V. , (2014), "Quasi-Monte Carlo Method for the Reduction of Computation Time to Denoise Image Corrupted By Salt and Pepper Noise", International Journal of Advance Research in Computer Science and Management Studies, 2(10), 166-172.

Siti Arpah Ahmad, Mohd Nasir Taib, Noor Elaiza Abdul Khalid and Haslina Taib, (2012), "An Analysis of Image Enhancement Techniques for Dental X-ray Image Interpretation", International Journal of Machine Learning and Computing, 2(3), 292-297

Uroukov I. S., Speller R. and Olivo A., (2014), "Image enhancement of x-ray phase contrast images of micro objects", Signal Processing Research, 3, 24-30.

Zuiderveld K. , (1994), "Contrast Limited Adaptive Histogram Equalization", Academic Press.

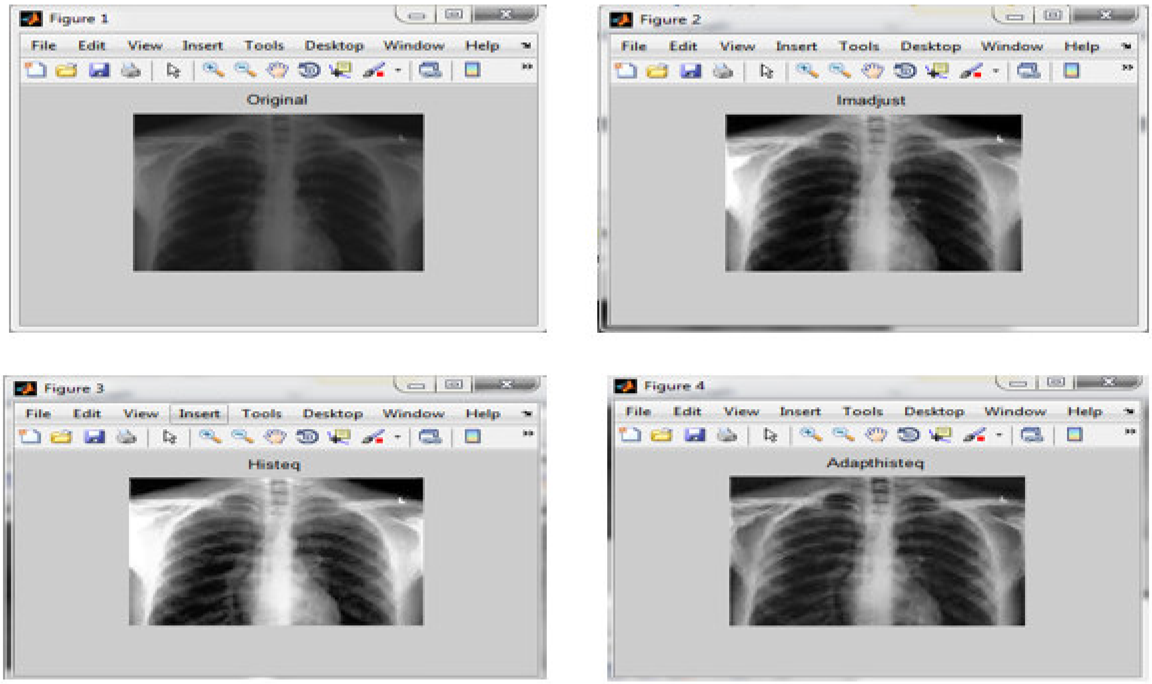

Figure 1, 2, 3 and 4. Original and three enhanced images by (Imadjust, HE and CLAHE) techniques respectively

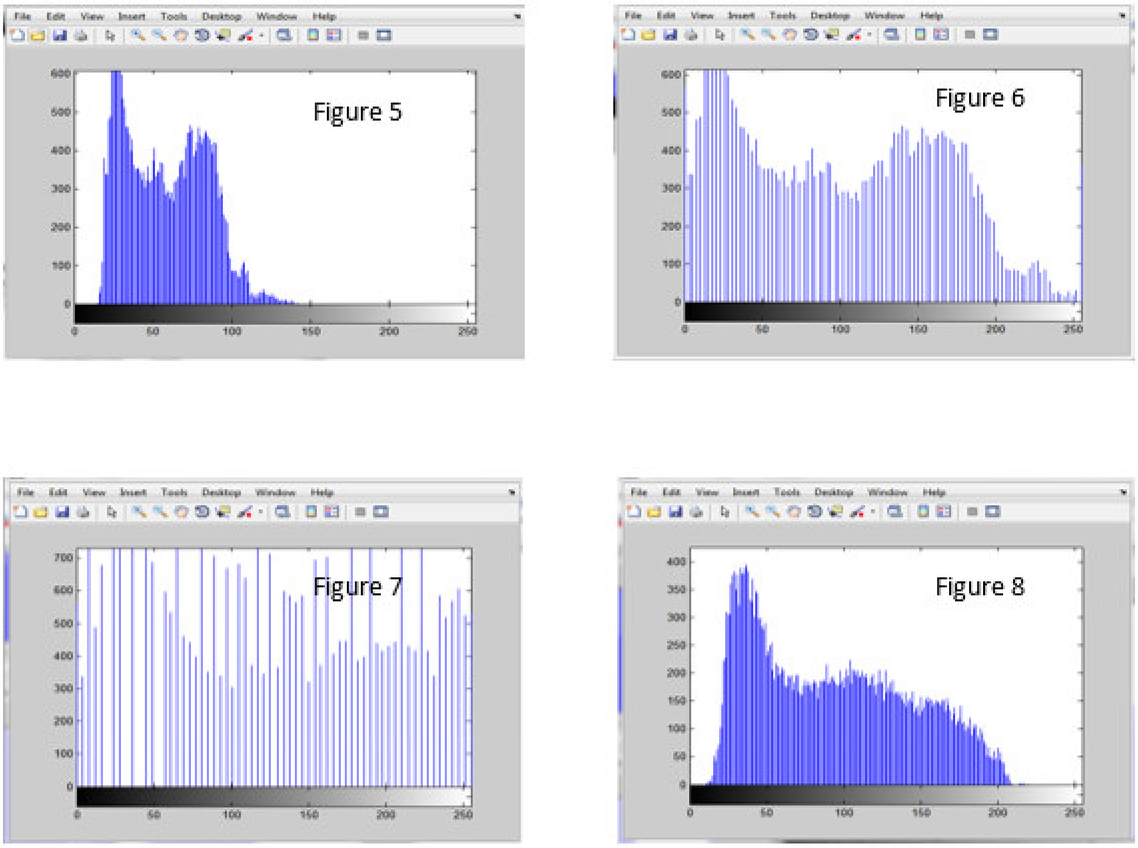

Figure 5,6,7 and 8. Histograms of original and 3 enhanced images by (Imadjust, HE and CLAHE) techniques respectively

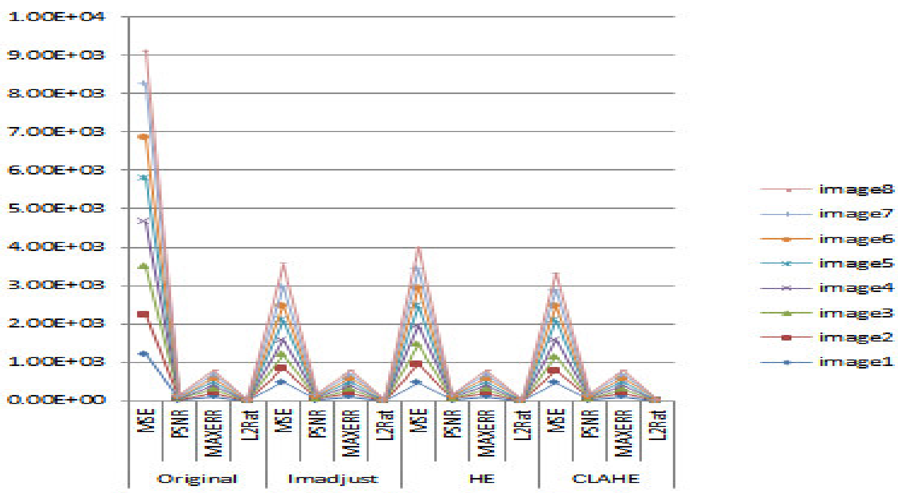

figure 9. stacked line with markers of quality measuresof original and enhaced images

Table 1: MSE, PSNR, MAXERR, R2rat values for 8 images

No.	Original				Imadjust				HE				CLAHE			
	MSE	PSNR	MAXERR	L2Rat	MSE	PSNR	MAXERR	L2Rat	MSE	PSNR	MAXERR	L2Rat	MSE	PSNR	MAXERR	L2Rat
1	1.2225e+03	17.258703	99	0.9703	494.8413	21.1861	99	0.9889	466.3377	21.4438	99	0.9902	460.9428	19.6125	99	0.9837
2	1.0544e+03	17.9006	99	0.9527	346.2548	22.7368	99	0.9931	475.1242	21.3627	99	0.9900	338.3926	22.8366	99	0.9930
3	1.2111e+03	17.2989	99	0.9481	365.2323	22.5051	99	0.9926	506.0020	21.0893	99	0.9891	354.4329	21.1028	99	0.9883
4	1.1523e+03	17.5152	99	0.9394	392.0373	22.9189	99	0.9933	512.4894	21.0340	99	0.9889	424.1810	21.8553	99	0.9809
5	1.1676e+03	17.4578	99	0.9452	496.5353	22.8605	99	0.9932	506.3669	21.0862	99	0.9891	501.6826	23.1265	99	0.9873
6	1.0282e+03	18.0102	99	0.9553	393.2414	21.0355	99	0.9934	484.2659	21.2800	99	0.9897	388.6017	22.1254	99	0.9818
7	1.4215e+03	16.6034	99	0.9070	482.2121	20.9814	99	0.9984	479.2815	21.3249	99	0.9898	431.3111	21.8773	99	0.9887
8	872.1323	18.7250	99	0.9639	572.1238	21.7831	99	0.9944	574.2812	20.5396	99	0.9874	420.5047	21.8931	99	0.9708