MRI Medical Images Enhancement based on Histogram Equalization and Adaptive Histogram Equalization

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Abstract)—*MRI medical images recently considered one of the most widely utilized for disease diagnostic in the field of medicinal. With this signification the MRI images suffers from contrast degradations. These contrast degradations in MRI images can be solved with image contrast enhancement techniques to make it more suitable for medical applications. The image contrast enhancement techniques are used to enhance the visibility quality of internal human body texture in magnetic resonance imaging (MRI) images. In this paper the Histogram Equalization (HE) and Adaptive Histogram Equalization (AHE) are applied to improve the contrast of MRI medical images. Experimental results have achieved good efficiency to improve the contrast of MRI medical images with very high quality. Various measures quality like MSE, PSNR and SNR are been taken into account for evaluation the quality of enhanced MRI medical images.*

Keywords—*MRI medical images, Contrast enhancement, Histogram Equalization, Adaptive Histogram Equalization.*

I. INTRODUCTION

Presently, the modern imaging techniques for disease diagnostic depends frequently on Magnetic resonance (MRI), x-ray images, and computer tomography (CT), which has extremely expanded for imaging the internal human body structure[1].

MRI medical images are being utilized a long time ago to image the internal structures of human body. It is considered one of the most widely utilized diagnostics methods in the field of medicinal. MRI presented good imaging between the diverse elastic tissues of the human body, so make it especially helpful in imaging the muscles, brain, heart, and the cancers compared to another medicinal imaging methods like computed tomography (CT) . Although there are several advantages of MRI technique, but it generates contrast degradations in MRI images [2].

Image enhancement procedure consists of a set of techniques which attempt to enhance the visual form of an image to be it suitable for analysis and processing [3]. One of the processes for applying the image enhancement is manipulate the image contrast. Contrast enhancement techniques for example the histogram equalization and the adaptive histogram equalization, which have been commonly used to enhance the contrast of the medical images [4].

Recently, there are a number of researches that are concerned to enhance the contrast of medical images based on contrast enhancement techniques. Raihan et al [5] proposed an enhancement technique for medicine images depend on morphological transformation, the morphological transformation is applied on medical images to improve the contrast and visual quality. A disk formed mask is utilized in the Top Hat and Bottom Hat transform. Yogesh Rao et al [6] proposed a new medicinal image enhancement technique depend on wavelets for generate high resolution medicinal images. Seungjong Kim et al [7] proposed a novel medicinal image enhancement method by using edge-based de-noising and adaptive non-linear histogram stretching.

In this paper, we apply the histogram equalization and adaptive histogram equalization for enhancement the contrast of MRI medical images. This paper structured as follows. Section II presented the medical images contrast enhancement techniques. Section III provided the experimental results. Section IV presented the conclusions of this paper.

II. MEDICAL IMAGES CONTRAST ENHANCEMENT TECHNIQUES

The image enhancement techniques were intended to enhance the perception of information. Therefore, the edge or contrast enhancement improves an image for assessment by a human viewer. Some of the medical contrast enhancement techniques such as linear contrast enhancement, Histogram Equalization (HE), Adaptive Histogram Equalization (AHE) and the Contrast Limited Adaptive Histogram Equalization (CLAHE) [8].

A. Histogram Equalization

Histogram equalization is a useful technique for enhancing the visual of a degradation contrast image. The theoretic basis for the histogram equalization depends on the probability theory, the histogram treats as a probability distribution of the gray levels. An image I represents as a discrete function, the intensities of the pixels variety from 0 to $L-1$.

Typically L equals to 256 for 8-bit image. A probability of appearance of gray level r_k is

$$p_r(r_k) = \frac{n_k}{n} \qquad k = 0,1,\ldots,L-1, \quad \ldots\ldots (1)$$

where n_k represents the pixels number which have gray levels r_k , $0 \le r_k \le 1$, and n represents a total number of the pixels in an image. The cumulative distribution process corresponding to p_r is defined as

$$s_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j) = \sum_{j=0}^{k} \frac{n_k}{n} \quad k = 0,1,\ldots,L-1, \quad \ldots\ldots (2)$$

where $T(r_k)$ represents the transforming of every pixel value r_k to a level s_k. $T(r_k)$ represents the single valued and the monotone increasing process of r_k, and $0 \le T(r_k) \le 1$ for $0 \le rk \le 1$. As a result, the resulting image have obtained through transforming the original pixel intensities r_k to the new pixel intensities s_k via the function $T(r_k)$. The process consisting of the following steps:

1. Calculate the n_k of the original image, k = 0,1, . . .,L – 1.
2. Compute the histogram of the original image by equation (1).
3. Calculate the cumulative distribution process by equation (2).
4. Compute the resulted gray level through rounds to the nearest integer.

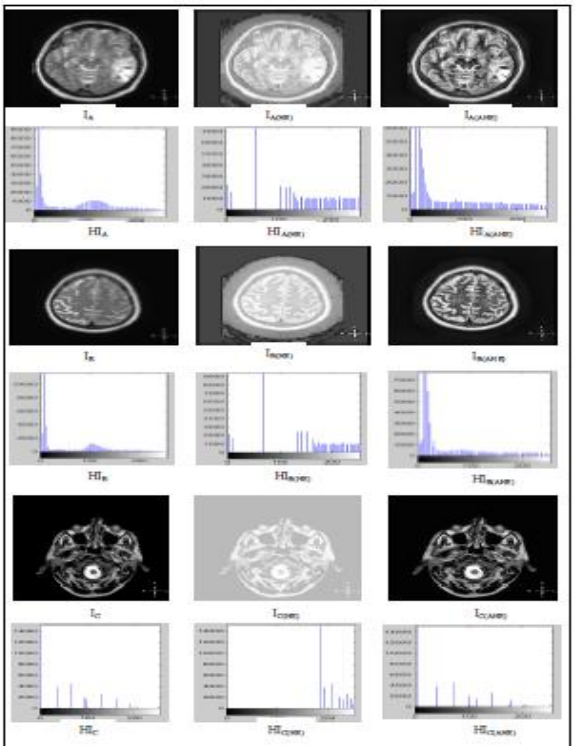
B. Adaptive Histogram Equalization

The adaptive histogram equalization is another technique used to enhance the contrast in the images. It distinct from normal histogram equalization through computes a number of histograms in the adaptive method, each equivalent to a distinct segment of the image, and utilizes them to redistribute the gray levels values of the image. Therefore the adaptive histogram equalization is suitable for enhancing the local contrast in each segment of the image. In adaptive histogram equalization each pixel is transformed depend on the histogram of the square surrounding pixels. The transformation function is exactly equivalent for normal histogram equalization but the adaptive histogram equalization technique depends on neighbourhood pixel values.

III. EXPERIMENTS AND RESULTS

In this section the evaluation of the results which obtained through implementation of the histogram equalization and adaptive histogram equalization on MRI medical images. We are use gray-MRI image of size 256×256 pixels as reference MRI images [9]. We have implemented the experiments by applying the HE and AHE on the collected of MRI medical images and compared the performance of the HE technique with the AHE technique. The selected sample MRI images with the corresponding contrast enhanced images and its histograms for each on are shown in Figure 1.

Fig 1: Results of Contrast Enhancement techniques for MRI medical images based on Histogram Equalization and Adaptive Histogram Equalization.



As shown in Figure (1), the images (I_A, $I_{A(HE)}$, $I_{A(AHE)}$) are presented in first row where I_A represents reference MRI image, $I_{A(HE)}$ represents the enhanced MRI image after apply histogram equalization and $I_{A(AHE)}$ represents the enhanced MRI image after apply adaptive histogram equalization. The (HI_A, $HI_{A(HE)}$, $HI_{A(AHE)}$) in second row represents the histogram of each image in the first row. In third row, fourth row, fifth row and sixth row presented another examples of MRI images, enhanced MRI images after apply histogram equalization, the enhanced MRI images after apply adaptive histogram equalization and the histograms of each image. To compare the performance of the HE and AHE on the selected MRI images, we calculated the MSE, PSNR and SNR values for the HE and AHE and are given in Table 1.

TABLE 1
COMPUTED THE MSE, PSNR AND SNR VALUES FOR THE SELECTED MRI IMAGES AFTER APPLY HE AND AHE TECHNIQUES.

Samples Images	HE			AHE		
	MSE	PSNR	SNR	MSE	PSNR	SNR
Sample 1	0.09	10.196	0.07	0.008	20.884	2.25
Sample 2	0.13	8.602	0.04	0.004	23.205	2.99
Sample 3	0.45	3.402	0.02	6.1481 e-04	32.112	3.04

Sample 4	0.22	6.472	0.00	0.019	17.082	0.54
Sample 5	0.10	9.822	0.11	0.006	21.839	2.49
Sample 6	0.30	5.125	0.00	8.1040 e-04	30.913	2.94
Sample 7	0.27	5.670	0.13	6.9577 e-04	31.575	3.61
Sample 8	0.36	4.334	0.00	0.009	20.105	0.44
Sample 9	0.48	3.105	0.00	0.007	21.573	1.22
Sample 10	0.34	4.604	0.10	6.6383 e-04	31.779	3.50

As noted in Figure (1) and Table (1), the enhanced MRI images by apply adaptive histogram equalization possess high level of visual quality compared with the enhanced MRI images by apply histogram equalization which possess less level of visual quality. As a result, it can be concluded the adaptive histogram equalization is better than histogram equalization for enhancing MRI medical images and we can see that enhanced MRI images by adaptive histogram equalization is much clearer than the original MRI images. Table 1 shows the comparison of all the MRI images based on MSE PSNR and SNR values where the MSE decreases when we use adaptive histogram equalization method and the PSNR, SNR values of the enhanced images has increased when we use adaptive histogram equalization.

IV. Conclusions

In this paper, we use the histogram equalization and adaptive histogram equalization for enhancement the contrast of MRI medical images. The quality of the enhanced MRI medical images is measured by using MSE, PSNR and SNR values. Based on the quality measures we concluded the adaptive histogram equalization is better than histogram equalization for enhancing MRI medical images and we can see that enhanced MRI images by adaptive histogram equalization is much clearer than the original MRI images. Hence, this technique can be utilized as a pre-processing for MRI medical image processing.

References

[1] Harold Ellis, Bari M Logan, Adrian K Dixon and David J Bowden, , *Human sectional anatomy*, 4th ed., Taylor & Francis Group, LLC , International Standard Book Number-13: 978-1-4987-0361-1 ,2015.

[2] Isaac H.Bankman, *Handbook of Medical Image Processing and Analysis*, 2nd Edition, Academic Press, ISBN 0123739047, San Diego, CA, USA, , 2008.

[3] PIKS Inside, *DIGITAL IMAGE PROCESSING*, 3rd Edition, John Wiley and Sons, Inc., New York. , 2001.

[4] Siti Arpah Ahmad, Mohd Nasir Taib, Noor Elaiza Abdul Khalid, and Haslina Taib, "An Analysis of Image Enhancement Techniques for Dental X-ray Image Interpretation," *International Journal of Machine Learning and Computing*, Vol. 2, No. 3, June 2012.

[5] Raihan Firoz, Md. Shahjahan Ali1, M. Nasir Uddin Khan, Md. Khalid Hossain, Md. Khairul Islam, Md. Shahinuzzaman, "Medical Image Enhancement Using Morphological Transformation," *Journal of Data Analysis and Information Processing* , 2016.

[6] Yogesh Rao, Nisha Sarwade, Roshan Makkar, "Denoising and Enhancement of Medical Images Using Wavelets in LabVIEW," I.J. Image, Graphics and Signal Processing, 2015.

[7] Seungjong Kim, Byongseok Min, Wongeun Oh and Jooheung Lee, "Medical Image Enhancement Algorithm Using Edge-Based Denoising and Adaptive Histogram Stretching", *International Journal of Bio-Science and Bio-Technology*, Vol.5, No.5 (2013), pp.25-38.

[8] Klaus D. Toennies, *Guide to Medical Image Analysis*, 2nd Edition, Springer-Verlag London Ltd., 2017.

[9] Prof. Jameelah H. Suad, Wurood A. Jbara, "SUBJECTIVE QUALITY ASSESSMENT OF NEW MEDICAL IMAGE DATABASE", *International Journal of Computer Engineering and Technology (IJCET)*, ISSN 0976-6367(Print), ISSN 0976 - 6375(Online), Volume 4, Issue 5, September - October (2013).