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TRIAD HISTOGRAM TO ENHANCE CHEST X-RAY IMAGE

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Abstract: The objective of Digital Image processing(DIP) refers to manipulate and enhance the image quality. There are plenty of image processing applications and problems are there, namely image representation enhancement, restoration and compression etc., In this paper, only three types of histogram modification methods (i.e. HE, AHE, & CLAHE) are discussed and implemented in MATLAB. The performance of these techniques is then compared using various parameters such as Peak signal to noise ratio (PSNR), Mean squared error (MSE), Signal to noise ratio (SNR), Absolute mean brightness error (AMBE) and Entropy. The results shows that CLAHE is efficient when compared to other two methods.

Keywords: DIP, Representation, Restoration, Compression, Medical Image Enhancement, Histogram.

I. INTRODUCTION

Whenever an image is converted from one shape to another some form of dilapidation occurs at the output. To improve such dilapidation, the application of restoration and/or enhancement can be used[1] . Restoration requires an a priori model of the degradation process. When no such knowledge is available the quality of an image may be improved for specific application by some adhoc process called image enhancement. The main purpose of digital image processing(DIP) method is to get better illustrative information for human elucidation. Moreover, the enhancement process does not augment the inborn information content in the data. But it does increase the active range of the selected features. So that they can be detected easily. Image enhancement includes graylevel and contrast manipulation, noise reduction, edge crispening and sharpening, filtering and so on. The greatest predicament in image enhancement is quantifying the standard for fortification. Filtering is one of the augmentation techniques which is used to get rid of extra noise from the picture. It is also used for image sharpening and smoothening. Mean intensity of the image may loss and computational time is high while enhance an image using local augmentation technique.These boundaries can be overcome by contrast enhancement. Not only this task,but also to make the image brighter, visual and detail worth full. Therefore a large number of image enhancement techniques are experimental and necessitate interactive procedures to obtain satisfactory results. However, image enhancement remains a very important topic because of its usefulness in all image processing applications. The remainder of this paper is organized as follows : In section 2 survey on existing works, section 3 presents the materials and methods. Results and discussions in section 4 . In section 5 conclusion to this paper is presented.

II. RELATED WORKS

Frosio and Borghese [2] have presented that the unsharp mask technique is one of the common UTILIZED METHODS for enhancing x-ray images. Jagatheeswari1 et al.[3] used a median filter (3□3 mask) with histogram equalization. To avoid impulse noise the enhanced image has been passed through a median filter. Sarage and Sagar Jambhorkar [4] had proposed filtering techniques to enhance the contrast of x-ray images which were distorted due to noise and blurring. This technique involved the use of different filters such as median filter to remove noise and mean filter to remove the high frequency details.Tiwari and Yardi [5] proposed an adaptive technique to improve the contrast quality of dental X-ray image using the Laplacian-of-a-Gaussian (LoG) filter. They had proposed to replace the fixed power transformation function from converting original image into a mid-range intensity image. Ritika [6] has proposed a technique to enhance the contrast of the medical images using mathematical morphology with the help of multiscale structuring element. However, there was a slight amplification of noise in this method. Kalyan Chatterjee et al [7] had implemented neuro-fuzzy inference system to obtain the clear image. Contrast enhancement was performed using Histogram equalization. Image enhancement using histogram equalisation was best suited for medical images.

Siti Arpah Ahmed et al [8] proposed an algorithm to analyse the image enhancement technique for dental X-ray image interpolation and compared four enhancement techniques namely,AHE,CLAHE,MAHE and SCLAHE. They concluded that the Adaptive Histogram Equalisation enhanced the image with better contrast. Mohammed et al [9] proposed spatial enhancement and power law transformation for enhancing medical images. It was concluded that as the power law increases, the brightness of the image increases. However, further enhancement can be made using other enhancement techniques

III.MATERIALS AND METHODS

The contrast stretching process plays an important role in enhancing the quality and contrast of medical images.

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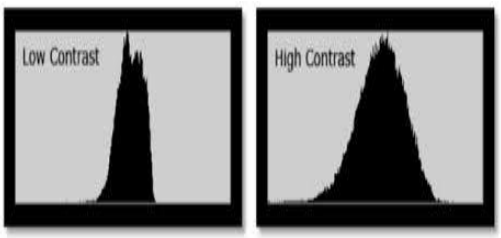
Medical images are usually fused, subject to high inconsistency and composed of different minor structure. In medicine all the data and related health information are stored as visual information in the form of x-rays, ultrasound or other scanned images for diagnosis and monitoring purposes. For medical images, especially x-ray chest images, texture feature extraction is a more difficult task as well as the x-ray images are gray-level images with poor contrast, high noise and important information often exist in a relatively small local area of the image, which are quite different from regular images. Regular texture extraction methods are not very suitable for x-ray images. The goal of medical information systems have often been defined as the delivery of the needed information at the right time, at the right place in order to improve the quality and efficiency of care process. If the original image is of rather low-contrast and does not contain much information stretching the contrast can only accomplish so much[10].
To enhance the contrast of chest x-ray image which is used in this study the techniques HEQ,AHEQ,CLAHEQ are used.

A Histogram Processing

Histogram processing is used in image enhancement. The information inherent in histogram can also used in other image processing application such as image segmentation and image compression. A histogram simply plots the frequency at which each grey-level occurs from 0 (black) to 255 (white). The histogram is a discrete function that is shown in figure. Histogram represents the frequency of occurrence of all gray-level in the image, that means it tell us how the values of individual pixel in an image are distributed. Histogram is given as :

$$h(r_k) = n_k/N$$

Where rk and nk are intensity level and number of pixels in image with intensity respectively. The contrast can be improved by scaling the graylevel of each pixel,so that image graylevel occupy entire dynamic range available. The operation may be called "histogram stretching." Fig.1



(a) **(b)**

B Histogram Equalization :

Histogram equalization is the most well-liked algorithm for contrast enhancement due to its efficacy and simplicity. It can be classified into two branches according to the transformation function used: global or local. Global histogram equalization is simple and fast, but its contrast-enhancement power is relatively low. Local histogram equalization, on the other hand, can enhance overall contrast more effectively, but the complexity of computation required is very high due to its fully overlapped sub-blocks Global histogram equalization method is simple and powerful, but it cannot adapt to local brightness features of the input image because it uses only global histogram information over the whole image. This fact limits the contrast-stretching ratio in some parts of the image, and causes significant contrast losses in the background and other small regions. To overcome this limitation, a local histogram-equalization method has been developed, which can also be termed block-overlapped histogram equalization.

C. Adaptive Histogram Equalization (AHE)

The standard histogram equalization is effective and simple method for contrast enhancement but for medical images most of the time it produces excessive contrast enhancement due to lack of control for the level of enhancement. Adaptive histogram equalization (AHE) is a computer image processing technique used to improve contrast in images. Moreover, the Histogram equalization amplifies the image noise and increases visual graininess or patchiness. To overcome these drawbacks, many variants of HE have been proposed. In medical imaging such as mammogram image enhancement local contrast are more important than global contrast. In such type of applications Global Histogram Equalization (GHE) is insufficient because it cannot deal with local features of original image due to its global nature. Adaptive Histogram Equalization (AHE) method will perform throughout all pixels in the entire image and maps gray level using local histograms, but it takes more time. The basic idea behind the scheme is to divide the image into a grid of rectangular contextual regions, and to apply a standard histogram equalization in each AHE is able to overcome the limitations of the standard equalization method and achieves a better presentation of information present in the image

D. Contrast Limited Adaptive Histogram Equalization (CLAHE)

A more advanced version of histogram equalization, adaptive histogram equalization, makes the assumption that the image varies significantly over its spatial extent.
CLAHE was originally developed for medical imaging and has proven to be successful for enhancement of low-contrast images such as x-ray images and portal films CLAHE, is an improved version of Adaptive Histogram Equalization (AHE).Both overcome the limitations of standard histogram equalization. The algorithm divides the image into smaller *tiles*, applies histogram equalization to each tile, then interpolates the results. MATLAB's implementation[11], adapthisteq(), includes limits on how much the contrast is allowed to be changed, called contrast-limited adaptive histogram equalization, or

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CLAHE for short. Again, CLAHE will modify the image in strange ways, but those may be better for certain tasks. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the histogram specified by the 'Distribution' parameter. The neighboring tiles are then combined using bilinear interpolation to eliminate artificially induced boundaries. The contrast, especially in homogeneous areas, can be limited to avoid amplifying any noise that might be present in the image.

To measure the image quality, various metrics are used in this study :

SNR, is defined as the ratio of signal power to the noise power, often expressed in decibels. Higher the SNR value betters the reconstructed image. Which is calculated by

$$\mathrm{SNR} = 10\log 10\left(\frac{Psignal}{Pnoise}\right) = \mathrm{Psignal,dB} - \mathrm{Pnoise,dB} \quad (1)$$

PSNR, is the estimation standard of the reconstructed image quality. It is measured in the decibels (dB) and it is given by

$$\mathrm{PSNR\ (dB)} = 10 \log_{10} (255 \times 255) / \mathrm{MSE} \quad (2)$$

Where the value 255 is the maximum possible value that can be attained by the image signal. Mean square error is defined as where M*N is the size of the original image. Higher the PSNR value betters the reconstructed image.
MSE, is the average squared difference between the reference signal and distorted signal. It is given by

$$\mathrm{MSE} = \frac{1}{mxn} \sum_{i=0}^{m-1} \sum_{i=0}^{i-1} [\mathrm{I}\ (i,j) - \mathrm{K}(i,j)]^2 \quad (3)$$

Entropy, is a useful tool to measure the richness of the details in the output image. It is given by

$$\mathrm{Ent}[p] = -\Sigma k=0\ (k)\log 2\ p\ (k) \quad (4)$$

AMBE, is the difference between the brightness of the original image and enhanced image. It is given by

$$\mathrm{AMBE} = |\ E(x) - E(y)\ | \quad (5)$$

Where E(x) is the average intensity of the input image and E(y) is the average intensity of enhanced image. The value of AMBE should be as little as possible.

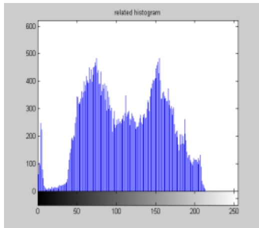
Procedure to enhance the input image :

- Download the chest X-ray image .
- save the image under .jpg extension
- apply the proposed methods (ie HE,AHE & CLAHE)
- generate the output images along with scatter diagram.
- measure the image quality, using the metrics.

IV. RESULTS & DISCUSSIONS

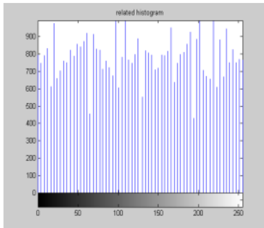
The three image enhancement techniques such as HE, AHE and ,CLAHE are implemented using MATLAB. The performance of all these image enhancement techniques are analyzed for chest X-ray image are presented.

(a)original



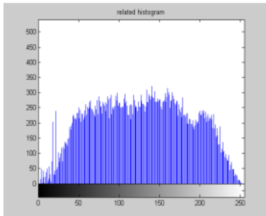
(b) related histogram

(c)HEQ



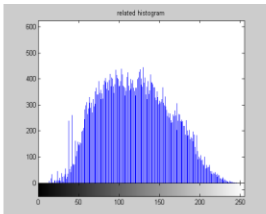
(d) related histogram

(e)AHE



(f) related histogram

(g)CLAHE



(h) related histogram

METHODS	SNR	PSNR	MSE	AMBE	ENTROPY
HE	15.134	18.164	121.12	6.243	5.761
AHE	17.212	18.298	98.10	4.134	7.312
CLAHE	19.321	20.562	57.12	1.310	2.320

Let us have a discussion about CLAHE how it is superior than HE and AHE.

- The HE technique is a global operation hence; it does not preserve the image brightness.

- The AHE Creates some unwanted blurring in edges.

- CLAHE, is an improved version of Adaptive Histogram Equalization (AHE).

- CLAHE was originally developed for medical imaging and has proven to be successful for enhancement of low-contrast images such as x-ray images and portal films.

- The contrast, especially in homogeneous areas, can be limited to avoid amplifying any noise that might be present in the image.

- The only difference between regular AHE and CLAHE is that there is one extra step to clip the histogram before the computation of its CDF as the mapping function is performed.

V. CONCLUSION

The three image enhancement techniques such as HE, AHE and ,CLAHE are implemented using MATLAB. The performance of all these image enhancement techniques are analyzed for chest X-ray images are presented. This paper concludes that the CLAHE gives much better results when compare to HE and AHE.

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