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Medical Images Enhancement by Homomorphic Filtering Equalization

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Abstract: Medical Imaging is one of the most important application areas of digital image processing. Processing of various medical images is very much helpful to visualize and extract more details from the image. Many techniques are available for enhancing the quality of medical image. For enhancement of medical images, Contrast Enhancement is one of the most acceptable methods. Different contrast enhancement techniques i.e. Linear Stretch, Histogram Equalization, Convolution mask enhancement, Region based enhancement, Adaptive enhancement are already available. Choice of Method depends on characteristics of image. This paper deals with contrast enhancement of X-Ray images and presents here a new approach for contrast enhancement based upon Adaptive Neighborhood technique. A hybrid methodology for enhancement has been presented. Comparative analysis of proposed technique against the existing major contrast enhancement techniques has been performed and results of proposed technique are promising.

Keywords: Histogram Equalization, Adaptive, Convolution, Mask, X-Ray, Neighborhood.

I. INTRODUCTION

Image Enhancement techniques usually are Problem Oriented Processing Techniques in which a specific algorithm is used to design for a particular type of application [1]. X-Ray images are Being used from a long time to image the internal structure of human body. It is one of the most widely used diagnostic tools in the field of medicine. X-Ray is used to capture the internal body structure images which help a lot to the radiologists in recognizing the internal problems. This is the most useful imaging modality to check for the bone fractures and other related anomalies. Though there are numerous advantages of X-Ray technology, but it generates low contrast images. One of the reasons for low contrast of X-ray images is presence of bulk amount of liquid in human body.

One can increase the power of X-Rays for capturing images but it may harm human body / bones. To make the images more visual and explanatory contrast may be increased on software and hardware level. With advancement of technology some X-Ray machines have also been introduced which can increase the contrast at their own with the help of software and hardware. As the X-Ray images are being used for diagnostic purposes, some software may also be designed to perform auto diagnosis. In general, the elucidation of X-Ray is being done manually by experienced interpreters of the medicine field. This work is time and manpower consuming.

Additionally, human elucidation of X-Ray images is very subjective, inconsistent and sometime predisposed. Image enhancement is also a significant part for automated X-Ray inspection systems. For making the X-Ray images more visual and explanatory some contrast enhancement techniques may be implemented in manual or auto-diagnose system.

II. EXISTING CONTRAST ENHANCEMENT METHODS

As per the reasons stated above contrast enhancement is commonly required for the captured medical images. A lot of techniques are already available for contrast enhancement of medical images. Commonly used techniques are:

A. Linear Stretch:

This is the simplest technique which enhances the contrast of an image. In this technique the intensity is increased uniformly for all the pixel values.

B. Histogram-Equalized:

Histogram equalization is a technique by which the dynamic range of the histogram of an image is increased. It flattens and stretches the dynamic range of the image's histogram and resulting in overall contrast improvement [2]. Histogram equalization assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. It improves contrast by obtaining a uniform histogram. This technique can be used on a whole image or just on a part of an image.

C. Convolution Mask enhancement:

This is a very common technique for contrast enhancement of digital images. Unsharp masking is commonly used for implementation of this contrast enhancement technique. Polesel [3] presented a new method for unsharp masking for contrast enhancement of images. The approach employs an adaptive filter that control the contribution of the sharpening path in such a way that contrast enhancement occurs in high detail areas and little or no image sharpening occurs in smooth areas.

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D. Enhancement by Background Removal:
A direct method of reducing the slowly varying portions of the image, to allow increased gray level variation in image details, is background subtraction. It is implemented by using low pass filters.

E. Adaptive Histogram Equalization:
In this method, the contrast of the image is enhanced by transforming the values in the intensity image. Adaptive Histogram Equalization attempts to overcome the limitations of global linear min-max windowing and global histogram equalization by providing most of the desired information in a single image which can be produced without manual intervention [4]. Unlike Histogram Equalization, it works on smaller regions individually. This approach makes the method more effective and thus popular for contrast enhancement of the greyscale and colour images.

III. PROPOSED ALGORITHM

Classical image enhancement techniques cannot adapt to the varying characteristics of images. The application of a global transform or a fixed operator to an entire image often yields poor results in at least some parts of the given image [5]. Morrow [6] has proposed a region based technique for improvement of results. Keeping in view, the shortcomings of the pre-build techniques, a modified algorithm is proposed based upon the adaptive region growing technique. This region growing technique involves the implementation of 8-connected approach and concept of seed selection. The whole algorithm is split into four major steps.

1) A seed point is selected on the image to be enhanced.
2) Based upon the selected seed point, whole image get split into foreground and background region.
3) Foreground region is then enhanced by equalizing histogram adaptively and then background region is added to the enhanced foreground.
4) Finally the enhanced image is obtained by adding gradient of original image to the image obtained in step 3.

The execution of algorithm will depend heavily upon the seed point. For splitting the image in different parts all the pixels of the image will be checked against some threshold defined in accordance to seed point gray value. Detailed steps of the algorithm are as following:
Step I: Select a pixel in the input image and make it a seed point. Add the seed pixel into an empty queue.
Step II: From top of the queue start finding immediate 8-connected neighbors of each unprocessed pixel and for each neighbor point, check whether the gray level value of that neighbor pixel is within the specified deviation from the seed pixel's gray level value. The deviation is specified in (1).

$$(f(m, n)-seed) / seed <= £ \text{ ------------------------}(1)$$

where f(m,n) is the gray level value of the current pixel and the threshold £ = 0.5 [7]. If the current pixel satisfies the criteria then it is added to the foreground queue, otherwise to background queue.
Step III: The Step II is repeated till all the pixels in the queue are processed. If some pixel is encountered that is already on the queue then ignore it and process the next pixel in the queue.
Step IV: Alter the gray level values of each pixel in the foreground buffer by adaptive histogram equalization of the foreground pixels.
Step V: Combine the pixels in foreground and background buffer to form the enhanced image.
Step VI: Obtain the gradient of the original image and add it to the enhanced image of Step V.
Step VII: Display the final enhanced image.

IV. PERFORMANCE EVALUATION

Performance evaluation of this algorithm was conducted on several X-Ray images on case-by case basis. Three low contrast X-Ray images have been taken as sample for implementing this proposed algorithm.

Evaluation has been done on the basis of
(a) signal-to noise ratio
(b) contrast-to-noise ratio
(c) Tennangrad measurement.

Results for the proposed algorithm are hereby compared against the Adaptive Histogram Equalization & Linear Stretch algorithms based upon the above said quality metrics SNR is the ratio of the mean of intensity difference between the signal (foreground) and the noise (background) to the standard deviation of the noise [8]. Contrast Resolution is much related to SNR. A higher value is always desired for SNR. CNR is the squared ratio of the difference in the mean intensity of the foreground and the background to the standard deviation of the background. TEN involves computing gradient magnitude at every location in image and sums all magnitudes greater than a threshold T[8]. While comparing results for Images, higher value of TEN and CNR represent better edges and contrast respectively.

V. RESULTS

A. Test Images
The first image i.e. Figure 1 is low contrast X-ray of left hand representing the bone structure of hand and specially the joints of fingers. The second image Figure 2 is another low contrast X-Ray capture of human chest to resolve the related medical issues. Final and third image is Figure 3, which is a low contrast phantom image of X-Ray and is being used to validate the results of proposed algorithm.

B. Results
The test images have been enhanced using proposed algorithm, Adaptive approach & Linear Stretching. These mentioned enhancement techniques produced following results for the above images: Figure (clockwise):a. Original Image b. Image Enhanced through proposed

method c. Enhanced through linear stretching d. Enhanced through adaptive enhancement. Represents visual results for the first test image (left hand). In visual analysis it is observed that contrast has been enhanced to various levels by all the algorithms but the proposed algorithm is enhancing the image more precisely in comparison to Adaptive HE & Linear Stretching. The human visualization is not considered as benchmark for image quality, so to evaluate the performance of above mentioned algorithms quality metrics have been calculated for the output images. Values for SNR, CNR and Tennanangrad Measurement have been calculated for the resultant images in comparison to the original image. The evaluation derives that Proposed Enhancement technique produces better quality values for enhanced image. Visual results and Quality test metrics for the mentioned algorithms have also been evaluated for the other two images i.e. Figure 2 and Figure 3. Table 2 is displaying metric values for the results of Figure 1. Figure 5 is representing visual results for the Figure 2, whereas Figure 6 is elaborating the results for Figure 3. Similarly Table 3 and Table 4 are the numerical values for the quality metrics of resultant images respectively The derived results are again giving better values to Proposed Enhancement method followed by Adaptive Enhancement. Linear Stretch method is also producing images having quality values, but less good than Adaptive Enhancement.

VI. CONCLUSION

In this paper, a seed dependent Adaptive Region Growing approach for contrast enhancement has been proposed for X-Ray images. On comparing this approach with the existing popular approaches of adaptive enhancement and linear stretching, it has been concluded that the proposed technique is giving much better results than the existing ones. Phantom X-Ray image has been used for justifying the visual results. Further, the technique is seed dependent so selection of seed is very important in this algorithm. A seed chosen in darker regions will give better results than the seed chosen in brighter region, because it is assumed that user will require enhancing the darker portions of the image.

VII. FUTURE SCOPE

Future work in this domain may include implementation of multiple seed points. The approach may be adopted for other type of medical images. Some denoising technique may also be included in the algorithm to improve the high noise images. Further some segmentation techniques may also be developed using the proposed technique as the preprocessing.

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