Implementation and Analysis of Contrast Enhancement Techniques for Medical Images

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Abstract **- Image enhancement which is one of the significant techniques in digital image processing plays important role in many fields. Image enhancement improves the visual appearance of an image or to convert an image to a form better suited for analysis by a human or machine. Contrast enhancement is one of the commonly used image enhancement method to improve the quality of image. In this paper, adaptive region growing technique is used for contrast enhancement of X-ray images. Comparative analysis of proposed technique against the existing major contrast enhancement techniques has been performed.**

Index Terms - AHE, Adaptive region growing technique,X-ray, Histogram Equalization

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I. INTRODUCTION

Medical Imaging is one of the most important application areas of digital image processing. 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.

In contrast enhancement,background detection is necessary in many applications to get clear and useful information from an image which may have been picturized in different conditions like poor lighting or bright lighting,moving or still etc.X-ray is one of the old techniques to take pictures of internal organs.X-ray is used to diagnose fractured bones or joint dislocation, guide orthopedic surgery, such as spine repair/fusion, joint replacement and fracture reductions , look for injury, infection, arthritis, abnormal bone growths and bony changes seen in metabolic conditions, assist in the detection and diagnosis of bone cancer, locate foreign objects in soft tissues around or in bones.

But problem with X-ray is very low contrast and sometimes visibility of image is not up to mark. If power of X-ray is increased, it may damage body's internal organs. So if contrast of X ray could be increased using software or hardware.Many Contrast Enhancement techniques are available to improve the quality of image. One such Enhancement technique is adaptive region growing technique. The region growing technique involves the implementation of 8-connected approach and seed selection.

II. EXISTING CONTRAST ENHANCEMENT TECHNIQUES

1. Enhancement by point processing - This is the simplest technique which enhances the contrast of an image.In this technique individual pixels are processed to yield another image.
2. Histogram equalization method - Histogram equalization is a technique by which the dynamic range of the histogram of an image is increased.Histogram equalization assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities.But this method produces undesirable effects when applied to images with low color depth [2].
3. Adaptive histogram equalization - In adaptive histogram equalization the contrast of an image is enhanced by transforming the values in the intensity image.Adaptive histogram equalization overcomes the limitations of global linear min-max windowing and global histogram equalization .This method is more effective and thus popular for contrast enhancement of the grayscale and color images [2][3].

III. PROPOSED ALGORITHM

Medical images need enhancement due to poor results of the diagnostic imaging machines. The region growing method is well developed technique for image segmentation.The general idea of the region growing method is to group pixels with the same or similar intensities to one region.The region growing method start with a seed pixel grows from this seed point by merging neighbouring pixels whose properties are most similar to the premerged region. If homogeneity criterion is satisfied the candidate pixel will be merged to the premerged region. The procedure is iterative at each step, a pixel is merged according to the homogeneity criterion.

Region growing methods can use 4 connected or 8 connected approach to make the regions.In this paper adaptive region growing uses 8 connected approach.

The algorithm is split into 4 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 adaptive histogram equalization 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.

Detailed steps of the algorithm are as following[1]:

Step I: Select a pixel in the input image and make it a seed point.Add the seed pixel into an empty queue.

StepII: 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. 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.

StepV: 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

Visual results have been displayed in the paper and performance evaluation has been done on the basis of
1. Signal to Noise Ratio
2. Contrast to Noise Ratio
3. Tenangrad Measurement

Results for the purposed algorithm are compared against the adaptive histogram equalization and linear stretch algorithms based upon the above quality metrics.

Table 1:Mathematical Formulas for Quality Factors

Sr.No.	Quality factor	Implementation
1.	Signal to Noise Ratio(SNR)	$\left\lvert\frac{\mu_{signal} - \mu_{noise}}{\sqrt{2}\sigma_{noise}}\right\rvert$
2.	Contrast to Noise Ratio(CNR)	$\left(\frac{\mu_{signal} - \mu_{noise}}{\sigma_{noise}}\right)^2$
3.	Tenangrad Measurement(TEN)	$\sum_y \sum_x [s(x,y)]^2 \; for \; s(x,y) > T$

SNR is the ratio of the mean of intensity difference between the signal and noise to the standard deviation of the noise.CNR is the squared ratio of the difference in the mean intensity of the signal and noise to the standard deviation of the noise. TEN evaluates the gradient magnitude at every location in the image and sums all magnitudes greater than a threshold T.

While comparing results for images, higher value of these quality metrics represent better enhancement.

V. RESULTS

1. Test Images

Fig. 1 is an image of low contrast X-Ray of Human skull. Fig. 2 is a low contrast phantom image of X-Ray. These are used to validate the results of proposed enhancement method.


Fig.1

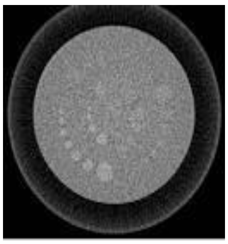
Fig.2

Fig.1 X-Ray Image of human skull
Fig.2 Phantom image

2. Results

The test images have been enhanced using proposed method, Adaptive Histogram Equalization approach & Linear Stretching. These mentioned enhancement techniques produced following results for the above images Fig. 3, represents visual results for the first test image. Fig. 4, represents visual results for the second test image. 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 been evaluated for the images. Table 2 is displaying metric values for the results of Fig. 3. Table 3 is displaying metric values for the results of Fig. 4.

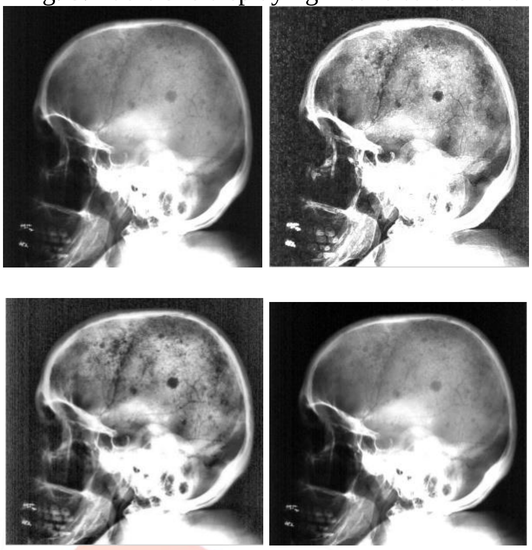

Fig.3 (clockwise) 3a.Original Image 3b.Image Enhanced through proposed method 3c.Enhanced through Linear Stretching 3d.Enhanced through Adaptive HE

Table 2: Performance Evaluation for Fig. 3

Algorithm / Quality Parameter	Adaptive HE	Linear Stretch	Proposed Algorithm
Signal to Noise Ratio	0.9294	0.1719	1.5111
Contrast to Noise Ratio	1.7278	0.0591	3.0221
Tenangrad Measurement	276103	244439	276103

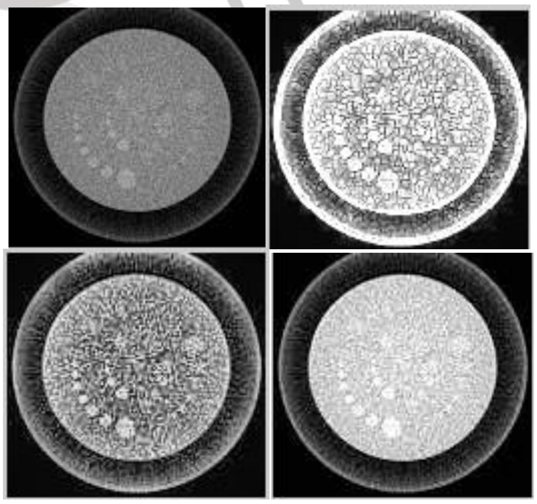

Fig. 4(clockwise) 4a.Original Image 4b.Image Enhanced through proposed method 4c.Enhanced through Linear Stretching 4d.Enhanced through Adaptive HE

Table 3: Performance Evaluation for Fig.4

Quality Parameter \ Algorithm	Adaptive HE	Linear Stretch	Proposed Algorithm
Signal to Noise Ratio	2.0618	1.2430	2.4337
Contrast to Noise Ratio	8.5021	3.0899	11.8454
Tenangrad Measurement	13614	13277	13935

VI. CONCLUSION

In this paper,seed based Adaptive Region Growing approach for contrast enhancement ofX-ray image has been proposed.On comparing the proposed methodology with the existing enhancement techniques,it has been concluded that the proposed technique is giving much better results than existing ones.For justifying the visual results, X-Ray of human skull and phantom images are used.

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