



## Analysis & Implementation of Contrast Enhancement Techniques Using Medical Image

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**Abstract**— *Image Enhancement is one of the most important application areas of digital image processing. Through various techniques, Useful Information can be extracted from image and visualized in a better way. One way is using Contrast Enhancement for enhancing features of image. There are different contrast enhancement techniques in image processing such as Linear Stretch, Histogram Equalization, Convolution mask enhancement, Region based enhancement, Adaptive enhancement. In all the above methods, the enhancement of the background detected image is done using Weber's law (modified Weber's law for compressed domain) These techniques are first implemented in gray scale and are then extended to color images by individually enhancing the color components. This paper deals with contrast enhancement of X-Ray images and presents here a new approach for contrast enhancement. Comparative analysis of proposed technique against the existing major contrast enhancement techniques has been performed. Here, the results of each technique are illustrated for various backgrounds, majority of them in poor lighting condition. MATLAB has been used to check results.*

**Keywords**— *Histogram, Equalization, Adaptive, Mask, X-Ray.*

### I. INTRODUCTION

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. A method for enhance the image is proposed; the methodology consists in solving an optimization problem that maximizes the average local contrast of an image. For Example, X-ray is one of the old techniques to take pictures of internal organs. It is in use since its invention. But only problem with X-ray is its contrast is very low and sometimes visibility of image is not upto 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, it is always considered as better option. Many Contrast Enhancement techniques are available to improve the quality of image. One such Enhancement technique is proposed using Adaptive neighborhood technique.

### II. EXISTING CONTRAST ENHANCEMENT TECHNIQUES

A lot of techniques are already available for contrast enhancement of images. Commonly used techniques are:

#### A. Enhancement by Point Processing

This is the simplest technique which enhances the contrast of an image. This technique manipulates the individual pixels of an image to yield another image. Point operations transform every single pixel in their input image into the resulting output pixel.

The basic transformation is shown in the figure-1 below. In the figure, the horizontal axis  $r$  represents the input pixel value, and the vertical axis  $s$  represents the output pixel value. As seen, there are three straight line segments used to transform an input pixel to its resulting output pixel value. Stated otherwise, the transformation from the input pixel value to the output pixel value is via the piecewise linear profile shown in the figure. The parameters specifying the contrast stretch mapping are the four values  $r_2, s_2, r_3, s_3$ , which determine the position of the intermediate straight line segment. Modifying any of these four values modifies the contrast stretch transformation. The values of  $r_1, s_1, r_4, s_4$  are fixed.

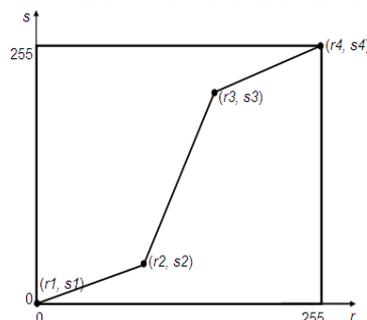


Figure-1

#### **B. Histogram-Equalized Method**

This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values the method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images, and to better detail in photographs that are over or under-exposed. A key advantage of the method is that it is a fairly straightforward technique and an invertible operator. So in theory, if the histogram equalization function is known, then the original histogram can be recovered. Histogram equalization often produces unrealistic effects in photographs; however it is very useful for scientific images like thermal, satellite or x-ray images. Often the same class of images that user would apply false-color to. Also histogram equalization can produce undesirable effects (like visible image gradient) when applied to images with low color depth.

#### **C. Enhancement using Frequency Domain methods**

**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.

#### **D. 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 grayscale and color 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).

$$(f(m, n) - \text{seed}) / \text{seed} \leq \epsilon(1)$$

Where  $f(m, n)$  is the gray level value of the current pixel and the threshold  $\epsilon = 0.5$  [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) Tenangrad measurement. Results for the proposed

algorithm are hereby compared against the Adaptive Histogram Equalization & Linear Stretch algorithms based upon the above said quality metrics.

TABLE 1: MATHEMATICAL FORMULAS FOR QUALITYFACTORS

Sr. No.	Quality Factor	Implementation
1.	Signal-to-Noise Ratio (SNR)	$\frac{ \mu_{signal} - \mu_{noise} }{\sqrt{2}\sigma_{noise}}$
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 (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 2 is low contrast X-Ray of foots representing the bone structure of foots and specially the joints of toes. The second image Figure 3 is another low contrast X- Ray capture of human skull to resolve the related medical issues. Final and third image is Figure 4, which is a low contrast phantom image of X-Ray and is being used to validate the results of proposed algorithm.



Figure 2: X-Ray Image of Foot



Figure 3: X-Ray Image of Human Skull

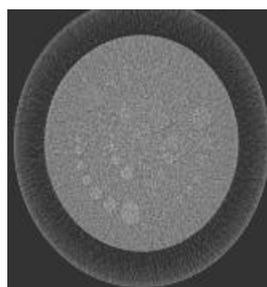


Figure 4: X-Ray Phantom Image

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 2, represents visual results for the first test image (foot) . 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 Tennenangrad 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 3 and Figure 4. Table 2 is displaying metric values for the results of Figure 2.

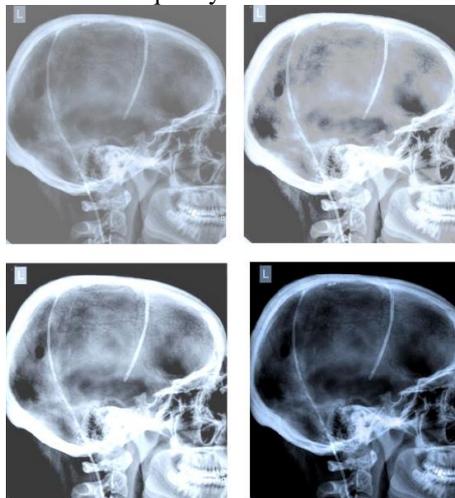


**FIGURE 2(CLOCKWISE): 2A. ORIGINAL IMAGE 2B. IMAGE ENHANCED THROUGH PROPOSED METHOD 2C. ENHANCED THROUGH LINEAR STRETCHING 2D. ENHANCED THROUGH ADAPTIVE ENHANCEMENT.**

TABLE 2: PERFORMANCE EVALUATION FOR FIGURE 2

Algorithm □ Quality Parameter	Adaptive HE	Linear Stretch	Proposed Algorithm
Signal-to-Noise Ratio	57.6920	98.7198	<b>132.9485</b>
Contrast-to-Noise Ratio	0.5934	1.7376	<b>3.1514</b>
Tenangrad Measurement	5954810	5605229	<b>6149159</b>

Figure 3 is representing visual results for the Figure 2, whereas Figure 4 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.



**FIGURE 3(CLOCKWISE): 3A. ORIGINAL IMAGE 3B. IMAGE ENHANCED THROUGH PROPOSED METHOD 3C. ENHANCED THROUGH LINEAR STRETCHING 3D. ENHANCED THROUGH ADAPTIVE ENHANCEMENT.**

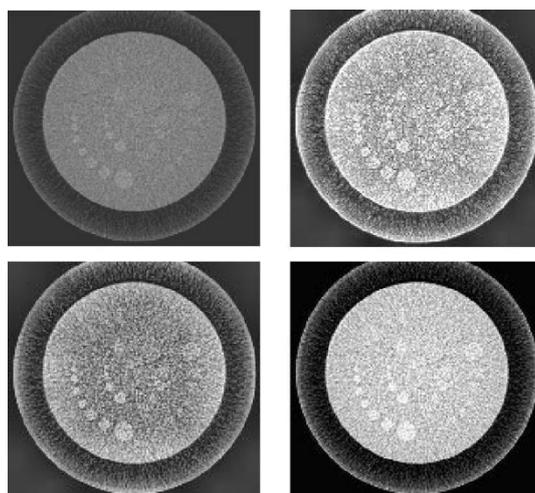


Figure 4(clockwise): 4a. Original Image 4b. Image Enhanced through proposed method 4c. Enhanced through linear stretching 4d. Enhanced through adaptive enhancement.

TABLE 3: PERFORMANCE EVALUATION FOR FIGURE 3

Algorithm □ Quality Parameter	Adaptive HE	Linear Stretch	Proposed Algorithm
Signal-to-Noise Ratio	146.5835	2.1076	<b>272.3978</b>
Contrast-to-Noise Ratio	2.9742	6.1486e-004	<b>10.2710</b>
Tenangrad Measurement	4010339	3781945	<b>4100675</b>

TABLE 4: PERFORMANCE EVALUATION FOR FIGURE 4

Algorithm □ Quality Parameter	Adaptive HE	Linear Stretch	Proposed Algorithm
Signal-to-Noise Ratio	159.1776	127.6371	<b>419.0631</b>
Contrast-to-Noise Ratio	2.5440	1.6357	<b>17.6322</b>
Tenangrad Measurement	4008918	3847973	<b>4128878</b>

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, Adaptive Region Growing approach for contrast enhancement has been proposed for images. On comparing this approach with the existing popular approaches image enhancements, it has been found that the Adaptive Region Growing approach is coming up with better results. Further, the technique is point dependent so selection of point is very important. A point chosen in darker regions will give better results than the point chosen in brighter region.

## 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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