Region Based Contrast Limited Adaptive HE with Additive Gradient for Contrast Enhancement of Medical Images (MRI)

Sonia Goyal, Seema

Abstract- Digital Image Processing has been widely implemented in Medical Imaging. Various branches of medical science are using digital image processing as an extensive process to visualize and extract more details from the image. Quality enhancement of medical images can be performed with the help of various techniques. Contrast Enhancement is one of the most acceptable methods for enhancement of medical images. Different contrast enhancement methods like Contrast Stretching, Histogram Equalization, AHE, CLAHE are already available. Method selection depends on characteristics of image. This paper works on low contrast MRI images and presents a hybrid methodology for image enhancement. Results of the proposed algorithm have been compared against the existing major contrast enhancement techniques and Region Based Adaptive Contrast Enhancement (RBACH) on both qualitative and quantitative basis.

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

I. INTRODUCTION

MRI stands for Magnetic resonance imaging. It is a medical imaging used in radiology to visualize detailed internal structures. MRI provides good contrast between the different soft tissue of the body, which makes it especially useful in imaging the brain, heart and cancer compared with other medical imaging techniques such as X-rays. MR signals produces a spectrum of resonance that corresponds to different molecules arrangement of the isotope being “excited”. This signature is used to diagnose certain metabolic disorder especially those affecting the brain. The reason of Low contrast MRI images might be taken of an endothelial cell, which might be low contrast & somewhat blurred.

To overcome above problems, a new hybrid method has been proposed for enhancement of the contrast range of MRI medical images.

II. EXISTING CONTRAST ENHANCEMENT TECHNIQUES

Due to capturing of low quality images, 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. Contrast Stretch is the simplest technique which enhances the contrast of an image.

Manuscript received May 30, 2011.

Sonia Goyal, Deptt. of CSE, YCOE, Punjabi University Campus, Talwandi Sabo, India. 9888115781, (E-Mail: Sonia_goyal786@yahoo.co.in)

Seema, Deptt. of CSE, YCOE, Punjabi University Campus, Talwandi Sabo, India

In this technique the intensity is increased uniformly for all the pixel values. 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 [1]. 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. Enhancement by Background Removal is 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. In Adaptive Histogram Equalization, the contrast of the image is enhanced by transforming the values in the intensity image. Traditionally histogram equalization is also a global technique in the sense of that the enhancement is based on the equalization of the histogram of the entire image [2]. 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 [3]. 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. The MMBEBHE (minimum mean brightness error bi-histogram equalization) is also a very popular method but the result of MMBEBHE is bad for the image with a lot of details. To overcome these drawbacks, a new method is proposed. In this method, image enhancement is performed by MMBEBHE based on a modified contrast stretching manipulation. While the image is the impulse noises present in the image are also enhanced. To avoid this effect, the enhanced image is passed through a median filter. The median filter is an effective method for the removal of impulse based noise on images

III. REGION GROWING METHODOLOGY

The region growing method is a well-developed technique for image segmentation. It postulates that neighboring pixels within the same region have similar intensity values. The general idea of the region growing method is to group pixels with the same or similar intensities to one region According to a given homogeneity criterion.

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication*

More precisely, the region growing method starts with a set of prespecified seed pixel(s) and grows from these seeds by merging neighboring pixels whose properties are most similar to the premerged region. If the 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. This process is repeated until no more voxels are assigned to the region.

IV. PROPOSED ALGORITHM

From the earlier studies it has been observed that medical images need enhancement due to poor results of the diagnostic imaging machines. The results get lowered due presence of heavy amount of water in human body. Image enhancement techniques lie in two different domains i.e. Spatial & Frequency. Various algorithms have been proposed on the basis of these techniques. An adaptive approach is suggestible for the contrast enhancement [2] [4] [5]. Some threshold value and criteria can be fixed which may derive the algorithm. Further, all the contrast enhancement methods enhances the noise too along the original image. To rectify this problem of contrast enhancement techniques, some noise reduction methodology has to be used. To implement adaptive methodology region growing is a suitable technique. Region growing methods can use 4-connected or 8-connected approach to make up the regions. The method presented in this paper is an adaptive region growing based methodology i.e. it clubs both the adaptive and region growing techniques and use 8-connected approach. The technique starts with selection of seed point and concludes with enhancement of edges by using gradient. Detailed steps of the algorithm are as following:

Step I. *Step I* Select a pixel in the input image that will work as the seed point. Add the seed pixel into an empty temporary buffer.

Step II. From the top of the buffer chose first point and find its immediate 8-connected neighbors and add them to temporary buffer.

Step III. Check for the Connectivity of pixels to the chosen point (Step II) on the basis of specified deviation from the seed pixel's gray level value. The deviation is specified as:

(f (m, n)-seed) / seed <= £

where f(m,n) is the gray level value of the current pixel and the threshold £ = 0.5 [6]. If the current pixel satisfies the criteria then it is added to the foreground queue, otherwise to background queue.

Step IV. Repeat Step II for all the unprocessed neighbors to grow up a region.

Step V. The Step II & III is repeated till all the pixels in the temporary buffer are processed. If some pixel is encountered that has already been processed then ignore it and process the next pixel in the buffer.

Step VI. Alter the gray level values of each pixel in the foreground buffer in proportion to mean ratio, that can be calculated as:

(mean-seed)/seed

Step VII. Perform Contrast limited adaptive histogram equalization on the altered foreground buffer and generate foreground image.

Step VIII. Expand the pixels of background buffer and generate background image.

Step IX. Combine the foreground and background image of Step VII and Step VIII to construct the complete image.

Step X. Obtain the gradient of the original image and add it to the image obtained in Step IX.

Step XI. Display the final enhanced image of Step X.

V. PERFORMANCE EVALUATION

Performance evaluation of this algorithm was conducted on several MRI images. Three low contrast MRI images have been taken as input for evaluating this proposed algorithm. Visual results have been displayed and quantitative comparison has been done on the basis of (a) signal-to-noise ratio (b) Entropy (c) Tenangrad measurement. Results for the proposed algorithm are hereby compared against the Contrast Limited Adaptive Histogram Equalization & RBACH [7] algorithms on the basis of mentioned quality metrics.

TABLE 1: MATHEMATICAL FORMULAS FOR QUALITY FACTORS

Sr. No.	Quality Factor	Implementation
1.	Signal-to-Noise Ratio (SNR)	$\frac{\lvert \mu_{signal} - \mu_{noise} \rvert}{\sqrt{2\sigma_{noise}}}$
2.	Entropy	$-\sum_{i=1}^{n} p(x_i)\log p(x_i)$
3.	Tenangrad Measurement (TEN)	$\sum_{y}\sum_{x}[S(x,y)]^2 \; for S(x,y) > T$

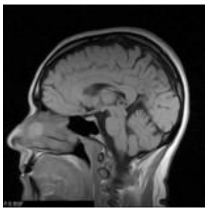
SNR is the ratio of the mean of intensity difference between the signal (foreground) and the noise (background) to the standard deviation of the noise [8]. A higher value is always desired for SNR. Entropy defines the overall quality of the image. TEN evaluates the gradient magnitude at every location in image and sums all magnitudes greater than a threshold T [8]. While comparing results for images, higher value of these quality metrics represent better enhancement.

VI. RESULTS

A. Test Images

The first image i.e. Figure 1 is low contrast MRI of human head and face representing the bone structure of head. The second image Figure 2 is another low contrast MRI capture of human chest, neck and backbone (side view) to resolve the related medical issues. Final and third image is Figure 3, which is a low contrast phantom image of MRI and is being used to validate the results of proposed algorithm.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication



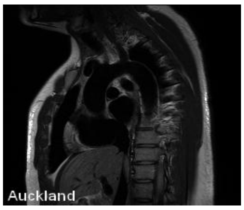


Figure 1: MRI Image of Head Figure 2: MRI image of Chest

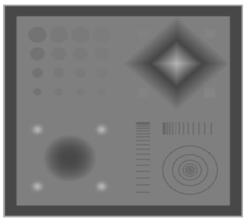


Figure 3: MRI Phantom image

B. Results

The test images have been enhanced using proposed algorithm, CLAHE & RBACH. These mentioned enhancement techniques produced following results for the above images:

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 CLAHE & RBACH. 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, Entropy and Tenanangrad Measurement have been calculated for the resultant images in comparison to the original image.

Table 2 is displaying metric values for the visual results obtained in Figure 4 for Figure 1.

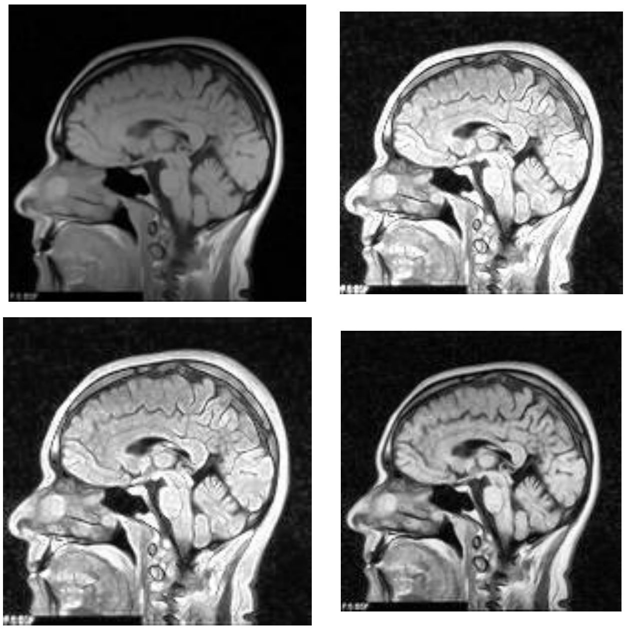


Figure 4(clockwise): 4a. Original Image 4b. Image Enhanced through proposed method 4c. Enhanced through CLAHE 4d. Enhanced through RBACH.

TABLE 2: PERFORMANCE EVALUATION FOR FIGURE 1

Algorithm→ Quality Parameter	**CLAHE**	**RBACH**	**Proposed Algorithm**
Signal-to-Noise Ratio (e+003)	1.3975	1.7685	**2.3517**
Entropy	6.9878	7.2093	**7.3752**
Tenangrad Measurement	3859284	3771883	**1.911e+009**

Figure 5 displays visual results for the Figure 2, whereas Figure 6 is representing the results for Figure 3. Similarly Table 3 and Table 4 are the numerical values for the quality metrics of resultant images respectively.

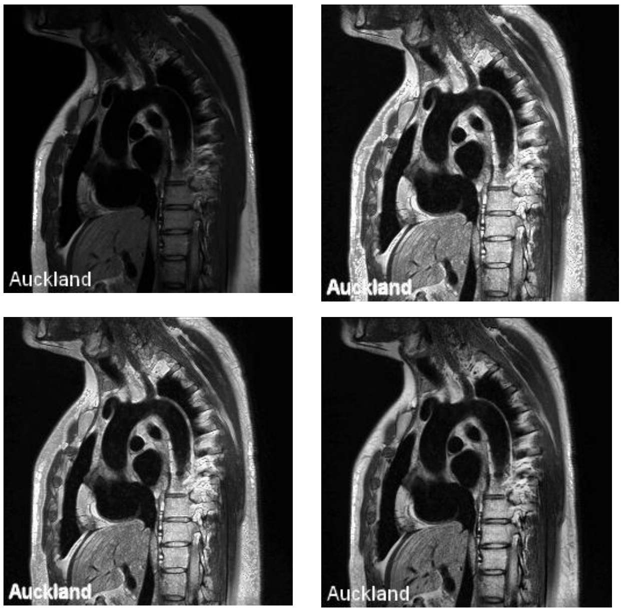


Figure 5(clockwise): 5a. Original Image 5b. Image Enhanced through proposed method 5c. Enhanced through CLAHE 5d. Enhanced through RBACH.

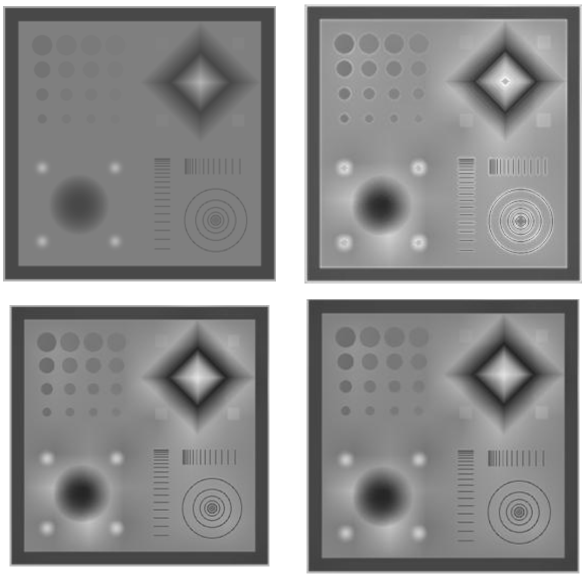


Figure 6(clockwise): 6a. Original Image 6b. Image Enhanced through proposed method 6c. Enhanced through CLAHE 6d. Enhanced through RBACH.

TABLE 3: PERFORMANCE EVALUATION FOR FIGURE 2

Algorithm→ Quality Parameter	CLAHE	RBACH	Proposed Algorithm
Signal-to-Noise Ratio (e+003)	0.9603	1.2944	**1.539**
Entropy	6.6352	6.9427	**7.0703**
Tenangrad Measurement	8312741	8665105	**2.2749e+009**

TABLE 4: PERFORMANCE EVALUATION FOR FIGURE 3

Algorithm→ Quality Parameter	CLAHE	RBACH	Proposed Algorithm
Signal-to-Noise Ratio (e+003)	202.09	348.35	**548.49**
Entropy	6.2639	6.4618	**6.4725**
Tenangrad Measurement	4861807	5.56e+006	**1.87e+009**

The derived results are again giving better values to Proposed Enhancement method followed by RBACH. CLAHE method is also producing images having quality values, but less good than Region Based Adaptive Enhancement.

VII. CONCLUSION

This paper is representing a seed based region growing approach for enhancement of MRI images. The approach has been fused with CLAHE, which is producing better results. On comparing the proposed methodology with the existing popular approaches of adaptive enhancement and region growing enhancement techniques, it has been concluded that the proposed technique is giving much better results than the existing ones. For justifying the visual results, phantom MRI image has been used.

FUTURE SCOPE

Future work in this domain may include some approach of automatic seed selection. Colored images may be selected for advanced devices. As contrast enhancement techniques also enhance noise, some denoising technique may also be included in the algorithm to improve the high noise images.

REFERENCES

1. Chen, Soong-Der and Ramli, Abd. Rahman, "Minimum Mean Brightness Error Bi-Histogram Eualization in Contrast Enhancement", IEEE Transactions on Consumer Electronics, Vol. 49, No. 4, 2003, pp. 1310-1319.
2. Zeyun, Yu. And Bajaj C. L. (2004), "A fast and adaptive method for image contrast enhancement", IEEE international conference on image processing (ICIP), Vol. 2, pp. 1001-1004.
3. Polesel, A. Ramponi, G. Mathews, V.J. Tele Media Int. Ltd., Frankfurt, "Image Enhancement via adaptive unsharp masking", IEEE Transactions on Image Processing, Vol. 9, Issue. 3, 2002, pp. 505-510
4. Jafar, I. and Ying, H. (2007), "A New Method for Image Contrast Enhancement based on Automatic Specification of Local Histograms", International Journal of Computer Science and Network Security (IJCSNS), Vol. 7, No. 7, pp 1-10
5. Srinivasan S. and Balram N. (2006), "Adaptive Contrast Enhancement Using local Region Stretching", Proceedings of ASID'06, pp. 152-155
6. Rangayan, R.M., "Biomedical Image Analysis", CRC Press, 2005, pp. 338, ISBN 0-8493-9695-6
7. Kanwal, N., Girdhar, A., Gupta, S., "Region Based Adaptive Contrast Enhancement of Medical X-Ray Images" Proceeding of 5th International Conference (IEEE) on Bioinformatics and Biomedical Engineering, (iCBBE) 2011 , May 2011, pp 1-5, ISBN: 978-1-4244-5088-6
8. Wei, Liyang, Kumar, Dinesh, Khemka, Animesh, Turlapti, Ram, Suri, Jasjit S. "Clinical Validation and Performance Evaluation of Enhancement Methods Acquired from Interventional C-ARM X-ray", Medical Imaging 2008: Image Processing. Edited by Reinhardt, Joseph M.; Pluim, Josien P. W. Proceedings of the SPIE, Volume 6914, 2008, pp. 691426-691426-8.