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REGION GROWING ADAPTIVE CONTRAST ENHANCEMENT OF MEDICAL MRI IMAGES

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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, Region based enhancement, Adaptive enhancement are already available. Choice of Method depends on characteristics of image. This paper deals with contrast enhancement of MRI 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 Histogram Equalization, MRI, Neighborhood.

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]. MRI 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. MRI medical imaging technique used in radiology to visualize detailed internal structures. MRI provides good contrast between the different soft tissues of the body, which make it especially useful in imaging the brain, muscles, the heart, and cancers compared with other medical imaging techniques such as computed tomography (CT) Though there are numerous advantages of MRI technology, but it generates low contrast images. One of the reasons for low contrast MRI images is presence of bulk amount of liquid in human body. One can increase the power of MRI 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 MRI machines have also been introduced which can increase the contrast at their own with the help of software and hardware. As the MRI images are being used for diagnostic purposes, some software may also be designed to perform auto diagnosis. In general, the elucidation of MRI is being done manually by experienced interpreters of the medicine field. It is time and manpower consuming work[4]. Additionally, human elucidation of MRI images is very subjective, inconsistent and sometime predisposed. Image enhancement is also a significant part for automated MRI inspection systems. For making the MRI images more visual and explanatory some contrast enhancement techniques may be implemented in manual or auto-diagnose system.

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:

1. 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.
2. 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.
3. 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 color images.

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:

1. Select a pixel in the input image and make it a seed point. Add the seed pixel into an empty queue.
2. 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 as:

$$(f(m, n)-seed) / seed <= \pounds$$

where $f(m,n)$ is the gray level value of the current pixel and the threshold $\pounds = 0.5$ [7]. If the current pixel satisfies the criteria then it is added to the foreground queue, otherwise to background queue.

3. The Step 2 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.
4. Alter the gray level values of each pixel in the foreground buffer by adaptive histogram equalization of the foreground pixels.
5. Combine the pixels in foreground and background buffer to form the enhanced image.
6. Obtain the gradient of the original image and add it to the enhanced image of Step 5.
7. Display the final enhanced image.

IMPLEMENTATION RESULTS

Test Images

The first image i.e. Figure 1 is low contrast MRI of Brain representing the bone structure of Brain The second image is Figure 2, which is a low contrast MRI of human body and is being used to validate the results of proposed algorithm.

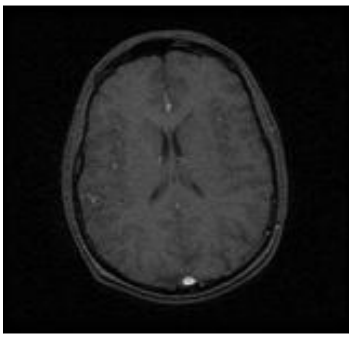

Figure 1. MRI of Brain

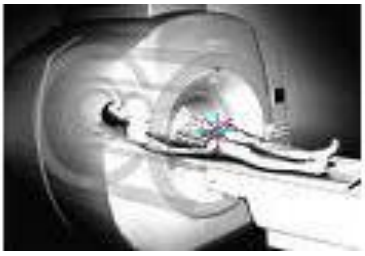

Figure 2. MRI of human body

Results

The test images have been enhanced using proposed algorithm, Linear Stretching, Adaptive approach & enhanced with adaptive gradient. These mentioned enhancement techniques produced following results for the above images:

Figure 1, represents visual results for the first test image (brain). 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 and enhance adaptive grediant. 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 to from the original image.

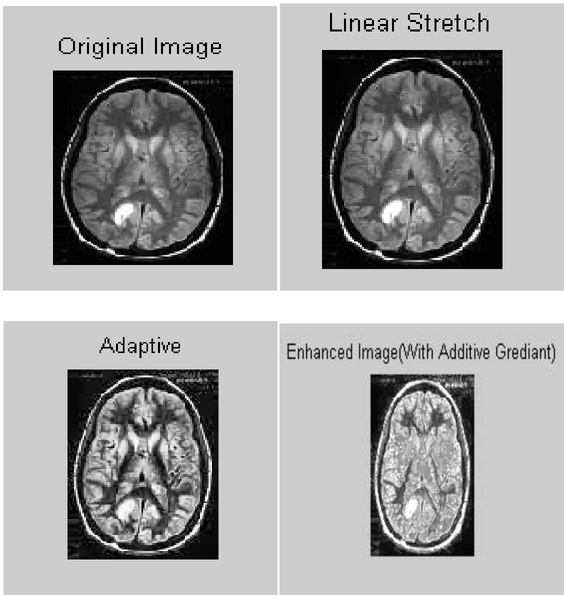

Figure 3(clockwise): 3a. Original Image 3b. linear stretch through proposed method 3c. Enhanced through adaptive enhancement. 3d. enhance image

Following is a table representing and comparing different quality tech-facts for the above output images.

Table 1: Performance Evaluation For Figure 1

Algorithm Quality Parameter	**Adaptive HE**	**Linear Stretch**	**Proposed Algorithm**
Signal-to-Noise Ratio	47.6920	96.7198	**142.9467**
Contrast-to-Noise Ratio	0.5956	1.6398	**3.6789**
Tenangrad Measurement	5958970	5567229	**6678959**

The evaluation derives that Proposed Enhancement technique produces better quality values for enhanced image. Visual results and Quality metrics for the mentioned algorithms have also been evaluated for the other two image i.e. Figure 2

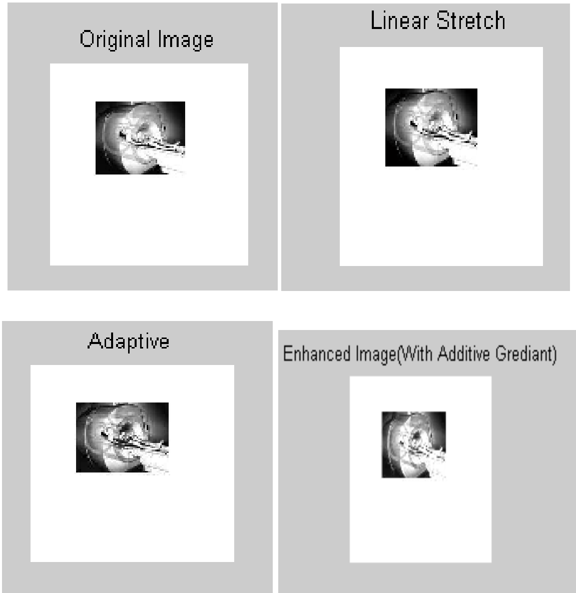

Figure 4(clockwise): 4a. Original Image 4b. linear stretch through proposed method 4c. Enhanced through adaptive enhancement. 4d. enhance image.

Table 2: Performance Evaluation For Figure 2

Algorithm Quality Parameter	**Adaptive HE**	**Linear Stretch**	**Proposed Algorithm**
Signal-to-Noise Ratio	166.5835	3.1776	**122.3978**
Contrast-to-Noise Ratio	2.9842	6.1956e-004	**17.7810**
Tenangrad Measurement	40678439	3798745	**3450675**

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.

CONCLUSION

In this paper, a seed dependent Adaptive Region Growing approach for contrast enhancement has been proposed for MRI 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. Human body MRI 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.

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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