Image Enhancement using Wavelet Fusion for Medical Image Processing

M. Mahesh, TR Revanth Kumar, B.Shoban Babu, J. Saikrishna

Abstract**:** ***Medical Image Enhancement Low contrast is the active study area that the obtained pictures suffer from noise and low contrast. Age of capturing equipment, bad illumination circumstances are the low contrast medical images. Thus, techniques of contrast improved performance are used before being used to enhance the contrast of medical images. Within a tiny range of pixel concentrations, contrast improvement algorithms enhance low contrast image. Low contrast image enhancement is accomplished using Equalization of Contrast Limited Adaptive Histogram. CLAHE image enhancement is used to enhance the quality of medical images with low contrast. DWT image, sub-bands such as LL, LH, HL, HH are decomposed. 2D Adaptive fusion image on discrete wavelet transformation is used to fuse the main and CLAHE output images. The efficiency of the output is calculated using merged image entropy and PSNR. It is discovered that the visual content of low contrast medical pictures is enhanced effectively on the basis of 2D DWT and adaptive Fusion.***

Keywords **:** ***AHE, CLAHE, DWT, PSNR, Adaptive Fusion, Entropy.***

I. INTRODUCTION

Good contrast is an important property in most image processing tasks. However, the conditions in which images are taken are not always optimal. Various factors such as the environment, the sensor limitations, lighting or the photographed object itself influence the final result in ways that are not always desirable, leading to a lack of visible detail and limited color range. In these situations, contrast improvement for a broad spectrum of instances of image processing becomes a useful preprocessing instrument. However, HE and its variants not only improve the contrast of the actual detail, but also the imperfections established during the image purchase, as they have no way of distinguishing between the two instances. This can be troublesome in some contexts such as when the image's contrast is extremely low or when the Relevant information can be confused readily with the noise. For this reason, some designing efforts in that field are now concentrated on reducing the apparition of that undesired data. There are mainly two points where the problem can be faced: right before or right after the equalization. If the noise reduction treatment is performed before or during the equalization process, relevant information might be lost together with the noise removed and can not be noticed and modified during the equalization process. On the other side, if after the equalization the noise reduction takes place, it is more difficult to remove because the improvement makes it more visible and meaningful. Together with the noise removed, equalization and relevant information can be lost and therefore can not be recognized and enhanced during equalization. On the other hand, if after the equalization the noise reduction takes place, it is harder to remove because the enhancement makes it more visible and relevant.

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II. RELATED WORK

In medical apps, IMAGE contrast improvement is essential. This is because in the diagnosis of many illnesses, visual examination of medical low contrast images is crucial. In apps such as mammography and chest radiography [1]-[2]. Due to the tiny variations in the coefficients of X-ray attenuation, the picture contrast is inherently low. Two commonly used techniques for worldwide image enhancement are linear contrast stretching and equalization of histograms. [2]–[3]. Local info may be more essential than worldwide contrast in diagnostic medical recent images. Equalization of adaptive histograms (AHE) [4]–[5] and Two well-known local improvement techniques are adaptive contrast enhancement (ACE) [6]–[7]. AHE algorithms map the gray pixel values using the local histogram relationships. While this enhances image contrast, intensive computations are required [8]. To decrease the computational burden, the bilinear interpolation method was developed [9]-[10]. It divides images into blocks.

III. HISTOGRAM EQUALIZATION

Adaptive histogram equalization (AHE) and low contrast adaptive histogram equalization (CLAHE) are more complicated and enhanced Standard variants of the histogram equalization. There is the issue with the conventional histogram equalization algorithm that the Contrast Improvement is based on the statistics of the entire image. Because of that, some levels will be used to depict parts of the image of low interest. Adaptive histogram equalization tries to minimize this problem by using a different histogram for each pixel in the image, calculated using a window with the intensity values immediately surrounding that pixel called contextual region. This provides an image in which objects with distinct values of intensity which lie in different intensity sub ranges They are visible around the same time. However, it should be noted that it does not guarantee that this relationship will be preserved after the equalization in case pixel a value is more than pixel
b value.

In addition, in practical terms, it is not feasible to compute a histogram for each pixel due to its computational cost. As a result, this strategy is mostly scrapped and instead [10], The picture is decomposed in fewer tiles and a histogram is calculated for each tile. Bilinear interpolation is used to create the transitions smoother in the final picture to avoid the limits of the tiles from appearing when applying the conversion to the distinct pixels. CLAHE is helpful in restricting the appearance of certain noise levels in areas of low gray variation. However, the reduced contrast enhancement in certain zones of this alternative could hide the presence of some significant data in the image.

Figure 1a) original image

AHE is different from the usual HE method because only one histogram is provided by HE. but AHE technique produces several histograms corresponding to distinct picture region and redistributes the image's intensity values. In the suggested technique, we use AHE technique for modified contrast improvement after using median filtering for picture sharpening and then minimizing the difference. We use "adapthisteq" in this recommended approach to adjust the contrast in a grayscale image. With most values in the center of the intensity spectrum, the initial picture has low contrast.

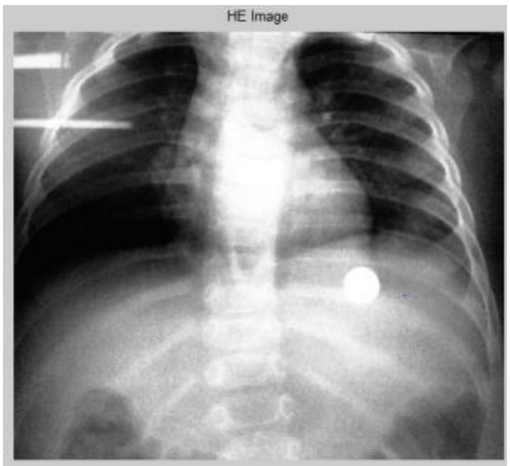


Figure 1b) Contrast Enhanced image

"Adapthisteq" generates an output picture that distributes values uniformly across the spectrum. Figure 2 demonstrates the noise presented image in which high frequency noise occurs in the noise picture as an additive noise and Gaussian noise. All four sub-bands of the fused image F are acquired simply by averaging the source image A & B wavelet coefficients.

$$F_{j,k} = \frac{A_{j,k}+B_{j,k})}{2} \quad \& \quad F_j = \frac{(A_j + (B_j)}{2} \quad \text{-------------(1)}$$

IV. PROPOSED ADAPTIVE FUSION

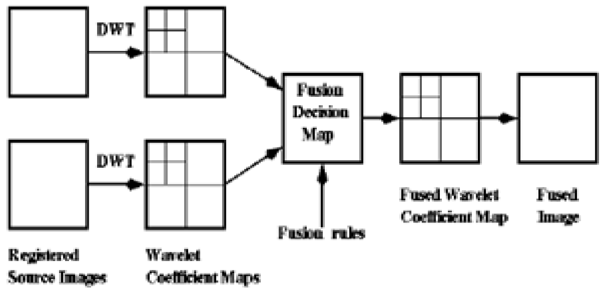


Fig 2: DWT Fusion

By using this (CLAHE) method, first low contrast medical image is boosted in this adaptive strategy but performed separately in RGB color space. Both improved picture and input image are transformed to gray level picture, then wavelet decomposition of source pictures up to level N is conducted. The low pass and high pass sub-bands are then combined using distinct pixel-level fusion methods to generate various enhanced pictures.. Then the transformation of the inverse wavelet is performed to obtain fused images of full size. Based on the entropy assessment, the outcomes of fused pictures at pixel level are compared. Finally, the outcomes of maximum entropy are chosen as the final improved picture. The current adaptive fusion method adopts the maximum pixel-level fusion rules to enhance the quality of the medical image using the Entropy tri-stage comparison as shown here.

H1>H2 & H1>H3 Image out= Pixel level Maxima
H1<H2 & H2>H3 then Image out = Pixel level Minima
H3>H1 & H3>H1 then Image out = Pixel level Averaging

It is found that the preference of adaptive fusion rule improves the effectiveness of medical image enhancement as the fusion findings are now independent of the surroundings

Steps of implementation included in the proposed algorithm

- **Step 1:** Choose low contrast input medical image.
- **Step 2:** Apply ADE or CLAHE to input image.
- **Step 3:** Apply 2D DWT to enhanced image then it is divided into four sub bands or contex regions .
- **Step 4:** Calculate the histogram intensity of each contextual regions.
- **Step 5:** set clip limits for clipping the histogram.
- **Step 6:** Each histogram has been modified by choosing a transfer function.
- **Step 7:** The theoretical equation for enhanced gray levels with Uniform Distribution can be provided as normal CLAHE technique.

$k =[k_{max} – k_{min}] * P(f) + k_{min}$ ----------------(2)

Where $k_{max} =$ Maximum pixel value
$k_{min} =$ Minimum pixel value
k is the value of computed pixel
P(f) = Cumulative

probability distribution

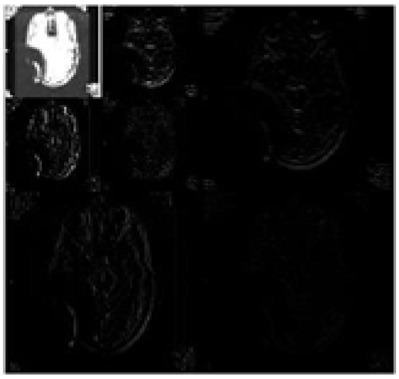


Fig 3(a): 2D Wavelet Decomposition of original NRI Image

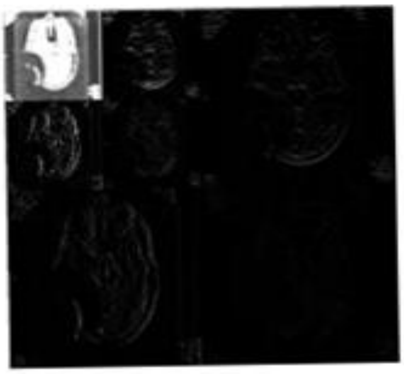


Fig 3(b): 2D Wavelet CLAHE Enhance Image decomposition

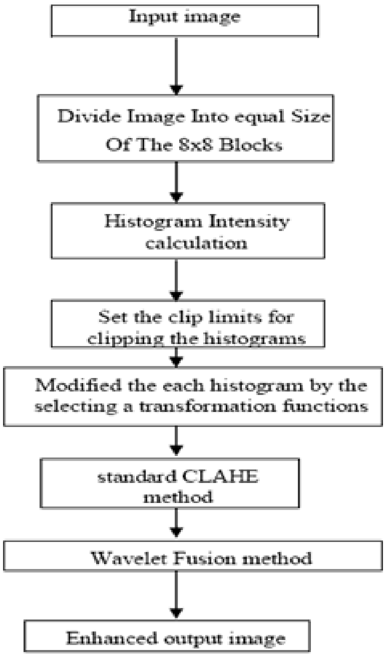


Figure 4: Enhanced image flow chart

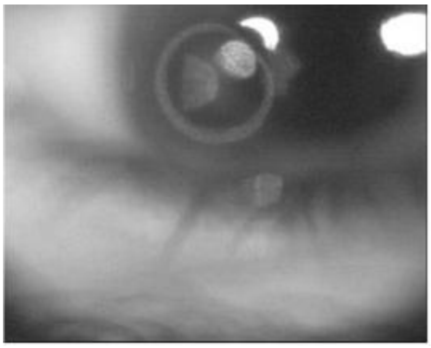


Figure 5: Noisy Human Eye Image

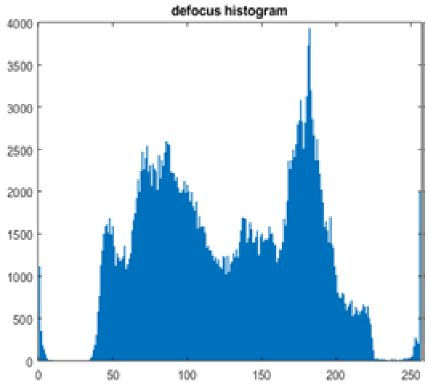


Figure 6: Histogram of Noisy Human Eye Image

V. RESULTS

The suggested algorithm is improved with MATLAB software.

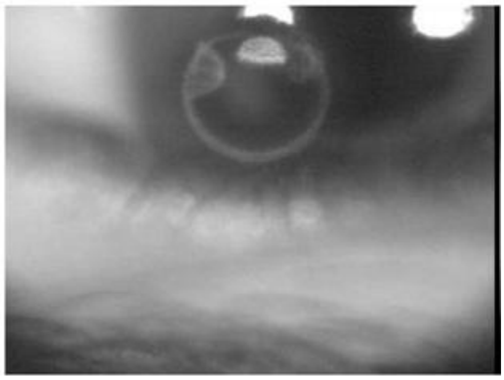


Figure 7(a): Input Eye Image

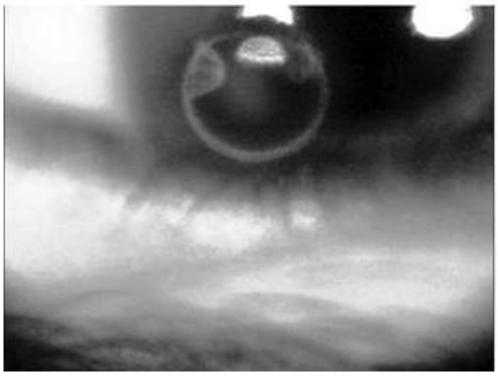


Figure 7(b): AHE output Image

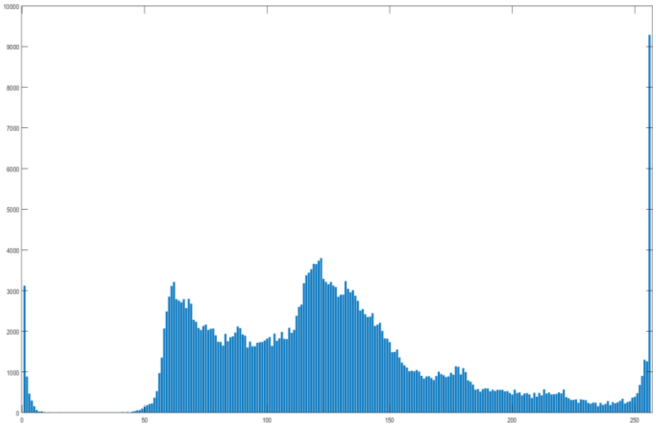


Figure 8: Histogram for AHE output Image

Figure 9(a): low contrast sonography Image

Figure 9(b): CLAHE Enhance Image

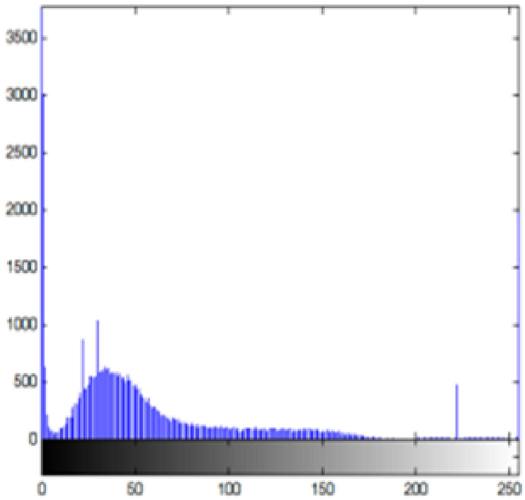


Figure 10(a) : input image Histogram

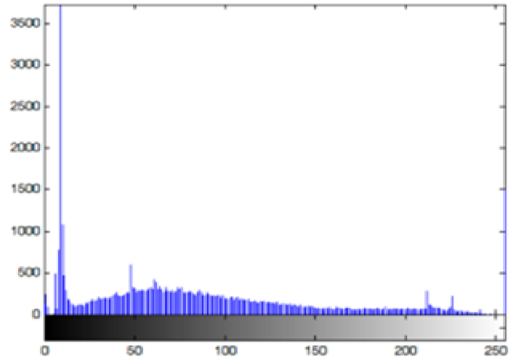


Figure 10(b): CLAHE histogram Image

VI. ADAPTIVE FUSION RESULTS

Figure 11(a): Minima Fusion Image

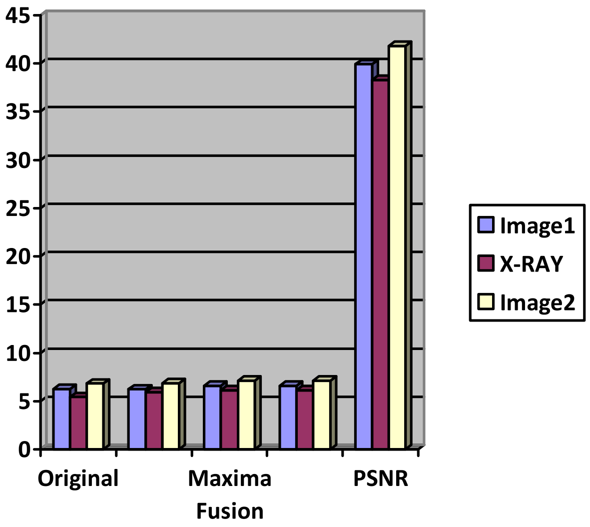
Figure 11(b): Maximum Fusion Image

Figure 11(c): Adaptive Fusion Image

Table 1 Entropy for Fusion methods for Sonography Image

S. No	Image	Original Image	Minima Fusion	Maxima Fusion	Proposed adaptive Fusion	PSNR in dB
1	Image 1	6.247	6.2214	6.57125	6.5712	39.909
2	X-RAY	5.42	5.911	6.121	6.12	38.29
3	Image 2	6.825	6.831	7.112	7.11	41.825

The figure, graph, chart can be written as per given below schedule.



VII. CONCLUSION

The image fusion strategies for medical images are outlined in this research. Designing the adaptive fusion rule on the basis of entropy assessment and PSNR is suggested. The CLAHE spatial domain techniques are used to produce the multi-focused picture set from a single medical picture. Performance of the two techniques of improvement, i.e. Based on the Entropy assessment, pixel level. Minima and Maxima are contrasted. The results show the algorithm's efficiency in conventional algorithms for contrast enhancement. The pictures obtained are visually pleasing, free of artifacts, and look natural. A broad range of pictures and video sequences are covered by the suggested technique. It also provides a level of controllability and adaptability through which it is possible to achieve distinct levels of contrast improvement.

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