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Image Enhancement Using Image Fusion and Image Processing Techniques

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Abstract: Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images. Appropriate choice of such techniques is greatly influenced by the imaging modality, task at hand and viewing conditions. This paper will provide a combination of two concepts, image fusion by DWT and digital image processing techniques. The enhanced image is validated using two parameters and this paper is implemented in MATLAB.

Keywords: Image Enhancement, Image Fusion, DWT, MATLAB.

I. INTRODUCTION

The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for a specific application. It accentuates or sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis. The enhancement doesn't increase the inherent information content of the data, but it increases the dynamic range of the chosen features so that they can be detected easily. The greatest difficulty in image enhancement is quantifying the criterion for enhancement and, therefore, a large number of image enhancement techniques are empirical and require interactive procedures to obtain satisfactory results. Image enhancement methods can be based on either spatial or frequency domain techniques.

Medical imaging fusion plays an important role in the diagnosis and treatment of patients with cancer who are receiving radiation therapy. Image fusion and registration are essential in the daily treatment planning duties of a medical dosimeters. The image fusion and registration process involves combining multimodality images to delineate the anatomical and physiological differences from one dataset to another.

Numerous fusion applications have appeared in medical imaging like simultaneous evaluation of CT, MRI, and/or PET images. Plenty of applications which use multisensory fusion of visible and infrared images have appeared in military, security, and surveillance areas. In the case of multiview fusion, a set of images of the same scene taken by the same sensor but from different viewpoints is fused to obtain an image with higher resolution than the sensor normally provides or to recover the 3D representation of the scene. The multitemporal approach recognizes two different aims. Images of the same scene are acquired at different times either to find and evaluate changes in the scene or to obtain a less degraded image of the scene. The former aim is common in medical imaging, especially in change detection of organs and tumors, and in remote sensing for monitoring land or forest exploitation. The acquisition period is usually months or years. The latter aim requires the different measurements to be much closer to each other, typically in the scale of seconds, and possibly under different conditions.

II. METHODOLOGY

The overview of the proposed methodology is shown in the fig.(1). The proposed system starts with reading two different images.

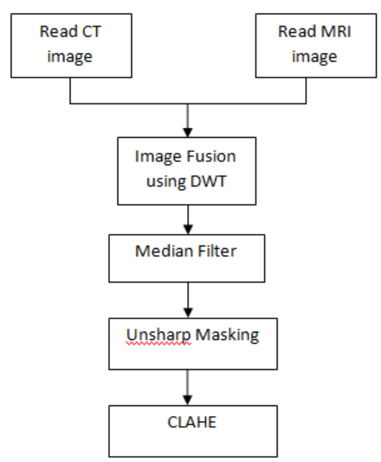


Figure 1: Overview of flowchart**.**

The blood sample input image is shown in fig.(1) above. The detailed version of methods as follows.

A. Image Fusion:

Image fusion is the process that combines information in multiple images of the same scene. These images may be captured from different sensors, acquired at different times, or having different spatial and spectral characteristics. The object of the image fusion is to retain the most desirable characteristics of each image. With the availability of multi-sensor data in many fields, image fusion has been receiving increasing attention in the researches for a wide spectrum of applications [1]. Here we use image fusion algorithm based on Wavelet Transform which faster developed was a multiresolution analysis image fusion. It has good time-frequency characteristics [2].

B. DISCRETE WAVELET TRANSFORM:

In comparison to other transforms, DWT transforms proved to be the best for image transformation. The frequency domain transform applied in this research Symlet-DWT [3]. In its basic operations, it decomposes the input signal into set of functions which are called wavelets. For image applications in transform domain, wavelet transform of image is computed, then modifications are made and at final step, inverse of wavelet is taken to get resulted image. We can select any family of wavelet from discrete or continuous wavelets like Haar, Coiflet, Symlet, and Daubechies. In discrete wavelets, we have different levels like 1-Dimension (D), 2-D … n-D. Original signal is decomposed twice in 2D-DWT in a way that makes use of scaling and wavelet functions of level 1 or DWT. Fig.5 explains it in detail.

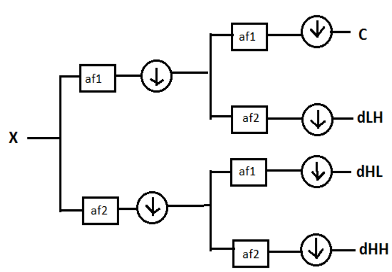


Figure 2: DWT

DWT analysis divides signal into two classes (i.e. Approximation and Detail) by signal decomposition for various frequency bands and scales.

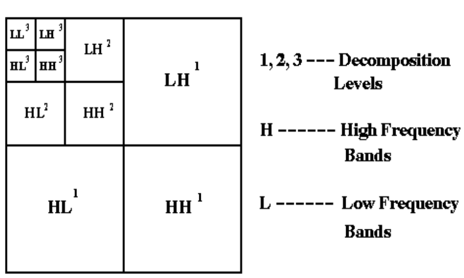


Figure 3: Three level decomposition.

DWT utilizes two function sets: scaling and wavelet which associate with low and high pass filters orderly. Such a decomposition manner bisects time separability. In other words, only half of the samples in a signal are sufficient to represent the whole signal, doubling the frequency separability.

C. Image Enhancement

The process of image enhancement [4] takes three consecutive steps as follows:

i. Median filter

We get one image after image fusion and now the image is enhanced by first applying two dimensional median filters [5]. A median filter is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges. Median filter replaces all the image pixels in the same time with the median of image pixel values in predefined (3-by-3) neighborhood of the given pixel. The Eq.(1) below represents a generalized function for any neighborhood.

$$f'(m, n) = med_{(-k \leq u,\, v \leq k)} \{f(m+u, n+v)\} \qquad (1)$$

where k=1, the median is calculated over 3-by-3 window, that is the size of filter. The noise in resulting image $f'(m, n)$ is reduced.

ii. Unsharp Masking

Now the filtered image is sharpened by using unsharp masking. The unsharp masking technique comes from a publishing industry process in which an image is sharpened by subtracting a blurred version of the image from itself. The function imsharpen in matlab returns an enhanced version of the grayscale input image A, where the image features, such as edges, have been sharpened. The Eq.(2) below represents unsharp masking function.

$$g(m, n) = f(m, n) - f_{smooth}(m, n). \qquad (2)$$

where $g(m, n)$ is enhanced image, $f_{smooth}(m, n)$ is smoothed image of $f(m, n)$.

iii. Contrast Limited Adaptive Histogram Equalization (CLAHE)

The final step in image enhancement is equalizing the contrast of the image. Using CLAHE [6] equalization of the contrast and clarity of the sharpened image is obtained. In CLAHE the part of the histogram that exceeds the clip limit is not discarded but it is redistributed equally among all histogram bins. The redistribution pushes some bins over the clip limit again, resulting in an effective clip limit that is larger than the prescribed limit and the exact value of which depends on the image.

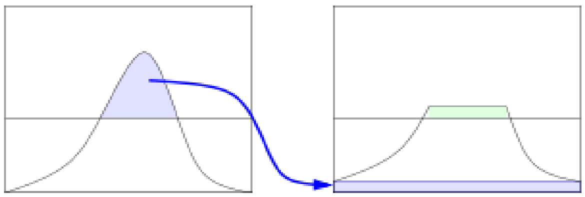


Figure 4: CLAHE distribution.

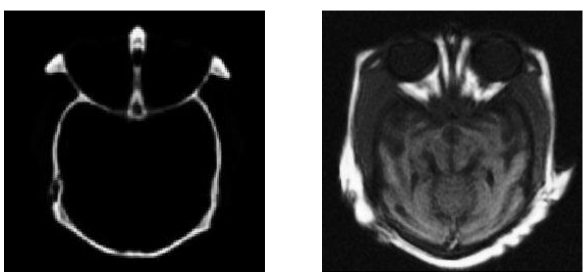
Using these consecutive steps the fused image is enhanced and the validation of fused and enhanced fused image is done in following section.

C. Validation of Enhanced Image

Calculate the PSNR and entropy values of both fused and enhanced fused images[7].

III. IMPLEMENTATION

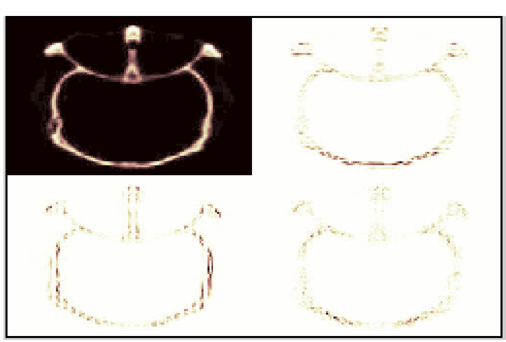
In this section the proposed method is implemented by taking a brain CT and MRI image in Joint Photographic Experts Group (JPEG) format. The size of both images must be same for image fusion therefore the dimension of two images are 256X256.



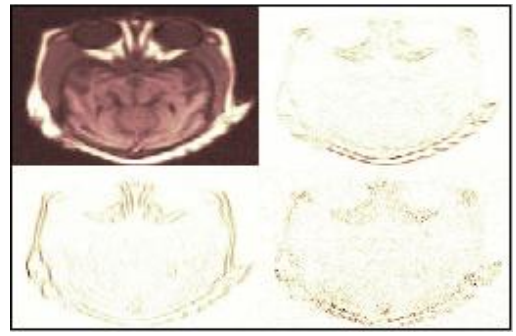
(a) (b)

Figure 5: Input Images a) CT b) MRI

Both the images are converted into grayscale and decomposed to single level using DWT. The wavelet used is Haar.



(a)



(b)

Figure 6: a) CT b) MRI Single level Decomposition using Haar DWT

After single level decomposition is performed all the bands are fused with both CT and MRI images and the result obtained is shown in fig.(7) Which is done in Matlab wavemenu [8].

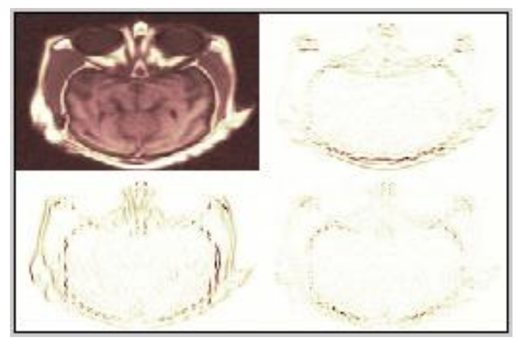


Figure 7: Fusion of decompositions

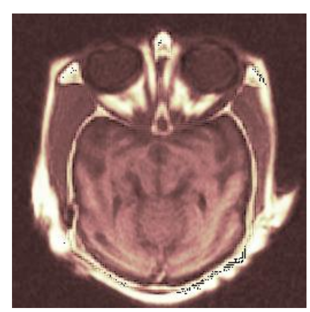
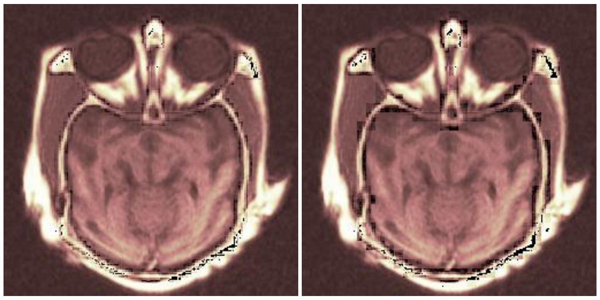


Figure 8: Single level inverse fused image

We get a single fused image after inverse DWT. Similarly two level and three level operations are also performed on input images and we get a single image. The below are the images after inverse two and three level inverse DWT.



(a) (b)

Figure 9: a) Two b) Three level inverse fused image.

Now the images are enhanced using the proposed method and we get the below image.

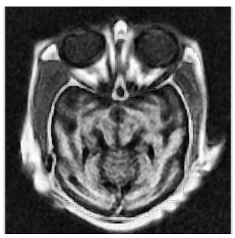


Figure 10: Enhanced single level image.

IV. RESULTS

The following parameters are calculated:

- Histogram:

An image histogram is a graphical representation of the number of pixels in an image as a function of their intensity. Greater is the histogram stretch greater is the contrast of the image[9]. In an image processing context, the histogram of an image normally refers to a histogram of the pixel intensity values. The histogram is a graph showing the number of pixels in an image at each different intensity value found in that image.

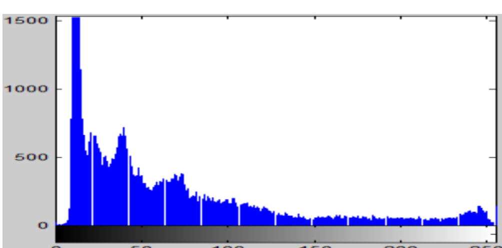


Figure 11 : Histogram of Fused image

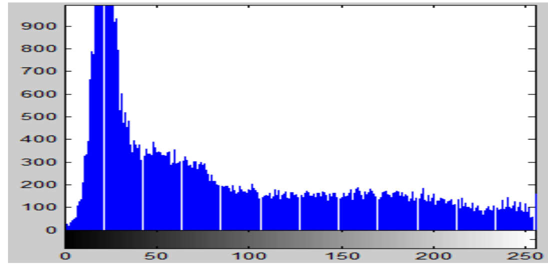


Figure 12: Histogram of fused enhanced image

The above shows the histogram result of fused and enhanced fused image.

- Peak-signal-to-noise-ratio (PSNR) which is evaluation standard of reconstructed image quality. The units of PSNR is decibels (dB) and is given by Eq.(6)

$$\text{PSNR} = 10\log\left(255^2/_{MSE}\right). \quad (3)$$

where MSE is mean square error.

Table 1: PSNR Values

Wavelet	Single Level	Two Level	Three Level
Haar	17.404	17.144	16.875
Daubechies	17.404	17.144	16.875
Coiflet	17.515	17.185	16.529
Symlet	17.492	17.163	16.368

The above table(1) show the PSNR values of different wavelets applied on the fused images for single , two and three level decompositions.

Table 2: Entropy Values

Wavelet	Single Level	Two Level	Three Level
Haar	7.431	7.449	7.465
Daubechies	7.431	7.449	7.465
Coiflet	7.429	7.444	7.483
Symlet	7.430	7.445	7.485

- Entropy a scalar value representing the entropy of an intensity image. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as

$$-\text{sum}(p.*\log2(p)) \quad (4)$$

where p contains the histogram counts. By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays.
The table(2) depicts the entropy values of the fused images.

V. Conclusion

In this paper a method is proposed for image enhancement by fusion of two images. By taking CT and MRI images of brain and decomposed the images into single level separately and then fused them before applying inverse DWT. Now we get a single image.

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. The choice of such techniques is a function of the specific task, image content, observer characteristics, and viewing conditions. In this paper a set of image processing techniques are used for image enhancement. The validations are also done by calculating histogram, PSNR and entropy values.

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