Application of Discrete Wavelet Transform in Medical Image Fusion

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Abstract— In radiology different scanning techniques such as X-rays, CT (computed Tomography), MRI (Magnetic Resonance Imaging) are used to evaluate the physical disorders of human organs. The goal of this paper is to improve the quality of the image by Medical Image Fusion which is more useful for image processing such as segmentation, feature extraction and object recognition. This paper mainly presents image fusion using Discrete Wavelet Transform (DWT) for high resolution and high accuracy using MATLAB which provides an effective image fusion with wavelet transform for preserving the future information of test images.

Key words: DWT, Effectiveness, Image quality, MATLAB, Medical images, Radiology

I. INTRODUCTION

In our paper the medical image fusion deals with the fusion of two medical images to improve the quality and view the images in various angles using some fusion coefficients. This type of fusion helps the physicians to diagnose the problems easier.

Image Fusion using Evolutionary Algorithm was proposed and the parameters are calculated using genetic algorithm [1]. Medical Image Fusion Techniques based on Neuro Fuzzy was explained by assigning the membership values for the linking strength of neurons [2]. Image Fusion Techniques based on DCT is determined by fusing RGB and gray scale image using DCT technique [3]. Implementation of Discrete Wavelet Transform for Multimodal Medical Image Fusion was experimented using fusion coefficients such as maximum, minimum and pixel averaging [4]. Design and Implementation of Pixel Level Medical Image Fusion published based on Discrete Multi Wavelet Transform (DMWT) [5].

Several co-efficient are there in Image Fusion. Presently fusion coefficients such as maximum, minimum and mean are used for fusing the images. In this paper fusion coefficients such as Up-down (UD) fusion, Down-up (DU) fusion, Left-right (LR) fusion and Right-left (RL) fusion are proposed to fuse the images in various angles to view the real time images without any difficulty and to improve the quality of the image.

II. IMAGE FUSION TECHNIQUES

The principle of image fusion using wavelets is to merge the wavelet decomposition of the two original images. The proposed fusion methods with 2-level decomposition are as follows:

A. Up-Down (UD) Fusion:

The Up-down fusion images are obtained from input image-A and input image-B. The size of the image is M×N. Where, M (by default '1') represents the number of rows and N represents the number of columns. The fused image is given by the equation,

$$C_f^2(a,b) = C_A^2(a,b) * (1-P) + C_B^2(a,b) * P \dots\dots (1)$$

B. Down-up (DU) Fusion:

The fused image of Down-up Fusion is given by the equation,

$$C_f^2(a,b) = C_A^2(a,b) * P + C_B^2(a,b) * (1-P) \dots\dots (2)$$

C. Left-right (LR) Fusion:

The Left-right fusion the size of the image is N×M. Where, N represents the number of rows and M (by default '1') represents the number of columns. The fused image is given in the equation (1)

D. Right -left (RL) Fusion:

The fused image of Right-left Fusion is given in the equation (2)

III. IMAGE FUSION BASED ON WAVELET TRANSFORM

The wavelet transform is a mathematical tool that can detect important features in image processing. It is used to decompose two dimensional (2D) signals such as 2D grayscale images into different resolution levels. The various transform techniques are time domain, frequency domain, wavelet analysis and etc., The DWT is spatial frequency decomposition that provides flexible resolution to analyze an image.

A. Block Diagram:

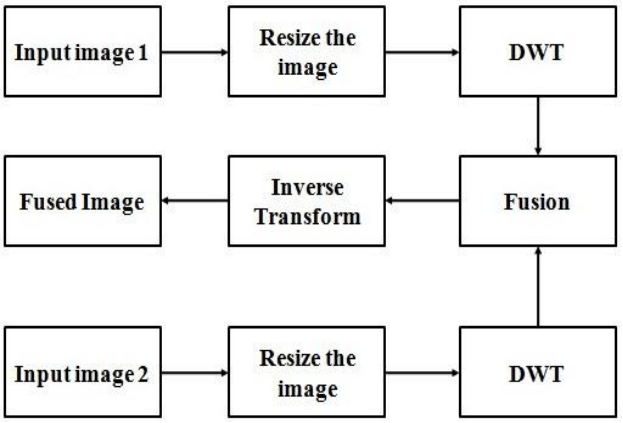

Fig. 1: Block diagram of Image Fusion

The two input medical images are resized to get the same pixel. The CT lung image (Input image 1) is resized and Discrete Wavelet Transform (DWT) is applied. The same procedure is repeated for CT image of lung with cancer (Input image 2). Both the CT normal image and cancer image lung are fused using the and fusion coefficients such as Up-down, Down-up, Left-right and Right-left after fusing inverse transform is taken and fused image is displayed as output.

B. Flow Chart:

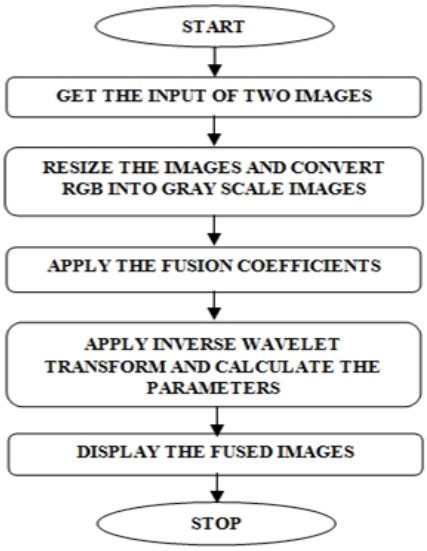

Fig. 2: Flow Chart of Image Fusion

There are three steps in this fusion technique. In Step-1, the input images are converted into grayscale images. In Step-2, fusion coefficients are applied to show the images in different views. In Step-3, some of the parameters are calculated for the fused image

IV. CALCULATION OF PARAMETERS

The parameters like Mean Square Error (MSE), Peak Signal to Noise Ratio, Elapsed time; Standard Deviation and Entropy are calculated to find accuracy of fused image.

A. MSE:

The mathematical equation for MSE (Mean Square Error) is given by,

$$MSE = \sum \frac{[a_{ij} - b_{ij}]}{i * j} \quad \ldots\ldots (3)$$

B. PSNR:

PSNR (Peak Signal to Noise Ratio) is the ratio between maximum powers of signal to the maximum power of noise. The PSNR value is denoted in dB (decibel) and it is given by,

$$PSNR = 10 \log_{10}\left(\frac{R^2}{MSE}\right) \quad \ldots\ldots (4)$$

C. Elapsed Time:

The elapsed time includes calculation of tic toc, CPU time and clock time which is denoted in seconds.

D. Standard Deviation:

The grayscale image is given by the clarity and contrast, greater the value greater will be the contrast. Lower the value, lesser will be the contrast. The equation is given as,

$$\sigma = \sqrt{\frac{1}{ij}\sum_{k=0}^{n}\sum_{l=0}^{m}(x(k,l) - \overline{x})} \quad \ldots\ldots (5)$$

E. Entropy:

Entropy defines the amount of information of an image, and the equation is given as,

$$H = -\sum P(i)\log_2\big(P(d_t)\big) \quad \ldots\ldots (6)$$

There are infinite numbers of values to calculate entropy for a single fused image. So the entropy value is not included in the table.

V. RESULTS

Fig. 3-6. Represents the upper region of the lung which is shown clearly in up-down fusion and the lower part in down-up fusion. Similarly left side of the image and right part of the image are shown clearly through left-right and right-left fusions respectively. Table1 gives the effectiveness of fused image. This proposed method of fusion finds the exact location of cancer in lung.

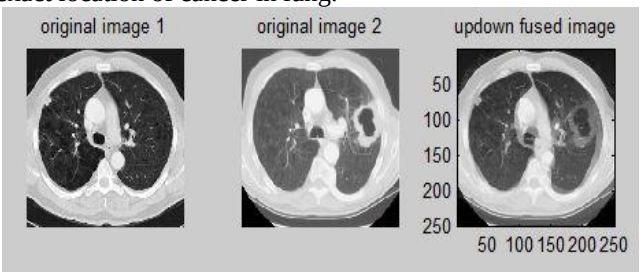

Fig. 3: Up-Down Fusion

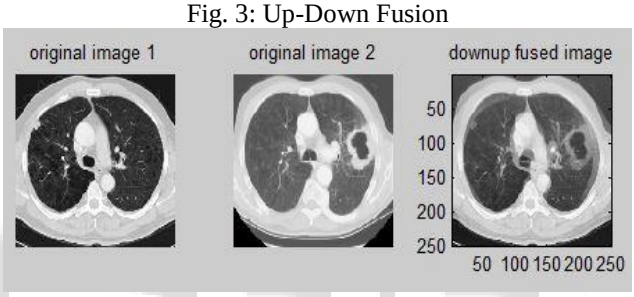

Fig. 4: Down-up Fusion

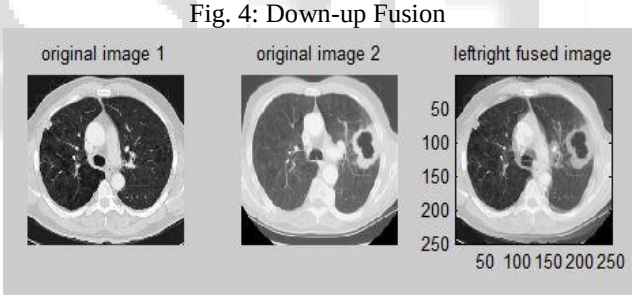

Fig. 5: Left-Right Fusion

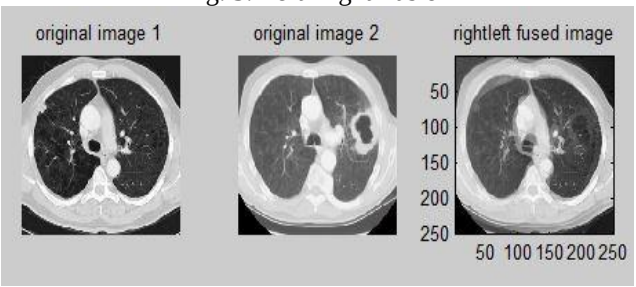

Fig. 6: Right-Left Fusion

	Up-down fusion	**Down-up fusion**	**Left-right fusion**	**Right-left fusion**
MSE	1500.70	169.16	1882.38	1458.92
PSNR	16.401	15.867	15.868	16.524
TIC TOC	0.999	0.997	1.004	0.996
CPU TIME	0.203	0.002	0.0313	0.047

CLOCK	1.005	1.001	1.01	1

Table 1: Values of Fused Image

VI. CONCLUSION

This paper mainly presents image fusion using Discrete Wavelet Transform (DWT) for high resolution and high accuracy using MATLAB which provides an effective image fusion with wavelet transform for preserving the future information of test images. The output of the fused image shows that the Discrete Wavelet Transform (DWT) is the most powerful technique to fuse two images into a single image and it takes time of less than or equal one second. So this technique helps the physician to identify cancer in short period of time.

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