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Medical Image Fusion using Discrete Wavelet Transform and Proposed Hybrid technique

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Abstract: ***In medical field applications there is a need for image fusion. A single method of examination about patient condition may not be sufficient to cure the disease. Fusion of CT and MRI images are used in this project. CT image of person gives information about hard tissues where as MRI gives soft tissues details. The fusion of both images gives detail information about the patient. This paper provides a new hybrid fusion method that improves the quality of image. The fusion techniques used in this project are DWT, DSWT and hybrid fusion method which is the combination of any two methods. The multi-modal fused image performance can be compared by using image Quality metrics like PSNR, MSE, RMSE, Entropy and other parameters. By observing the results, it can be proved that proposed method is more efficient for fusion.***

Keywords: Image fusion, DWT, DSWT, MRI, CT images

I. INTRODUCTION

Medical Image fusion is combining different images from single or different modalities in order to obtain accurate information about patient. Single Modality images like Computed Tomography (CT) image shows bone structures and lacks information about tissues; at the same time Magnetic Resonance Imaging (MRI) show information about tissues and outer bone structure details is absent. Positron Emission Tomography (PET) image gives details of flow of blood. Every single modality image is captured with different radiation power has its own complication in delivering required data. In order to control this, it is highly essential to acquire data from several modalities which is used for clinical detection. In this case, fusion is an approach used to mingle multimodality medical images such as CT, MRI, and PET etc. The fusion technique integrates appropriate data from many modalities of input images into a fused well defined image where the resultant image gives preferable knowledge in contrast with the input images which are used for fusion. Medical image fusion is categorized into three levels: pixel level, feature level, and decision level. Pixel level is based on pixel-by-pixel basis; produces an image by selecting the set of pixels in both input images, Medical image in feature level need the features like textures, edges and pixel intensities. Decision level is composition of numerous designs to give last fused image. The basic block diagram for medical image fusion is shown below.

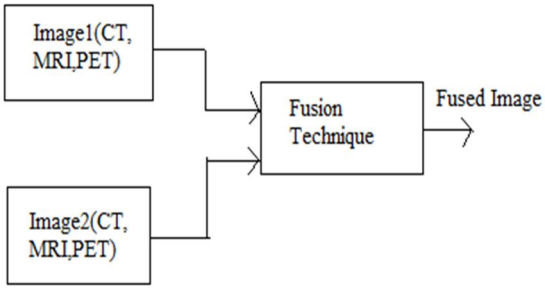

Fig.1.Basic Block diagram for Image fusion

Pixel image fusion is easy to apply but it found a loss of data and fading of corners. This can be upgraded by using multi scale disintegration. Medical image fusion using different transforms necessitate three phases: 1) Decomposing the input images into high and low frequency sub-band up to certain level. 2) Combining approximate and detailed coefficient using some fusion rules in order to obtain new fused coefficients. 3) Using the inverse transform a new image is formed.

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II. FUSION TECHNIQUES

The fusion techniques like averaging method, maximum method, minimum method, DWT and DSWT are used to obtain the fused image of CT and MRI images. The results of all these techniques are compared.

A. Averaging Method

For the pictures with high radiance and diversity this averaging method is used. Focus on each pixel value of input images and average of pixels of images is performed to acquire output. Picture element of each image is considered and calculate sum. The result is divided by number of input pictures. Average value obtained is then assigned to the corresponding pixel of the output image. The same procedure is repeated for all picture elements of the input images to be fused.

$$M(x,y)=\frac{Y_1(x,y)+Y_2(x,y)....Y_m(x,y)}{m}.....(1)$$

Where $Y_1(x,y),Y_2(x,y)……Y_m(x,y)$ are input images ,m is total number of input images for fusion process and $M(x,y)$ is the resultant output image. The disadvantage of this method is that both the original information and noisy data from the images are minimized because of averaging process and the original data will be discarded from the input images.

B. Maximum Method

Maximum method choose picture element with highest pixel intensity between given input images. Hand-Picked maximal pixel values from input figures are assigned to the corresponding picture elements of the output. Consider two input images A and B. Initially compare the pixel intensity of images C(x, y) and D(x, y) then pick pixels with high intensity and assigned to the corresponding picture element value of output image.

$$If\ C(x,y)\geq D(x,y) \quad \text{..... (2)}$$

$$Q(x, y) = C(x, y)$$

$$Else\ Q(x, y) = D(x, y)$$

Where C(x, y) & D(x, y) are input images and Q(x, y) is fused image. In comparison with simple averaging method it produces a more concentrated image but only high intensity pixels are taken into consideration.

C. Minimum Method

This method is used for images with low brightness values since it consider only pixels with low intensity values.

$$If\ M(x,y)\leq N(x,y) \quad \text{..... (3)}$$

$$S(x, y) = M(x, y)$$

$$Else\ S(x, y) = N(x, y)$$

Where $M(x, y)$ & $N(x, y)$ are input images and $S(x, y)$ is resultant fused image.

D. Discrete Wavelet Transform (DWT)

Discrete wavelet transform is one in which wavelets used are sampled discretely. Wavelets can be defined using two functions namely; father wavelet and mother wavelet. Corresponding to wavelet thesis, the father wavelet is accomplished as low-pass filter (LPF) and mother wavelet is executed as high-pass filter (HPF).

To evaluate 2-Dimensional DWT, initially achieve 1-Dimensional DWT on the rows of the input image matrix and then columns of the matrix by individually filtering and down sampling.

This results in 4 set of coefficients. In which one is approximation coefficient (LL) and three detail coefficients (LH – Horizontal, HL – Vertical, and HH – Diagonal).

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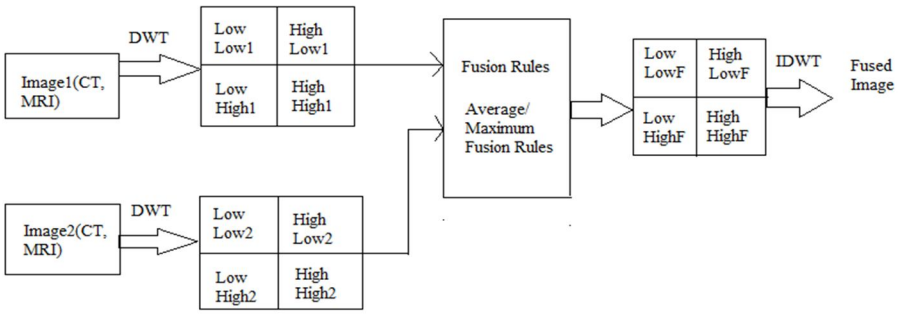

Fig. 2. Image fusion using DWT

E. Discrete Stationary Wavelet Transform (DSWT)

DSWT is a time consistent transform. Translation invariance is achieved by averaging understated DWT, called DSWT.
Steps involved in DSWT are:

1) Perform image registration to both MRI and CT image
2) Apply DSWT to both MRI &CT image.
3) Fuse corresponding band coefficients of both images using average or maximum method.
4) Perform inverse DSWT on the fused coefficients to obtain fused image.

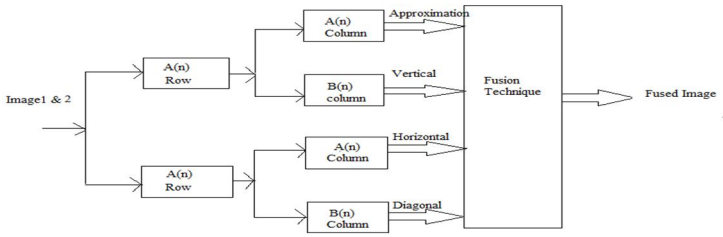

Fig. 3. Image fusion using DSWT

III. PROPOSED IMAGE FUSION TECHNIQUE

A. Hybrid Image Fusion

A single technique of fusion is not sufficient for image fusion as it have some disadvantages at any instant of time. There is a need of introducing a technique that utilizes the benefits of different fusion rules. Thus the hybrid image fusion is introduced. The two input images are given as inputs to both fusion techniques and the results obtained are again fused by using another fusion method. A single fusion technique cannot remove the distortion in the source images. The two hybrid fusion techniques presented in this paper are PCA-DWT-DSWT and Average-DWT-Maximum. Therefore Hybrid Image fusion leads to minimum Mean Square Error Value, Minimum NAE value and maximum Peak Signal to Noise Ratio (PSNR) value. The proposed work in this paper will describe the hybrid of three methods.

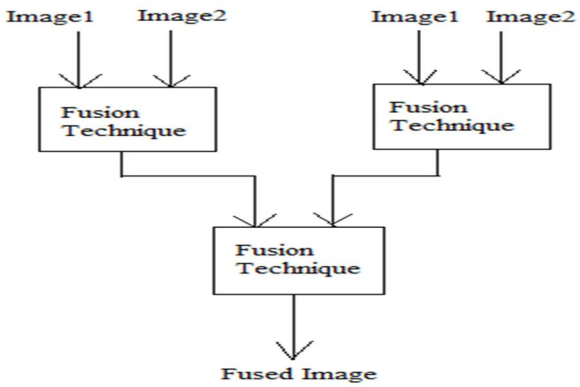

Fig. 4. Proposed Method

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IV. IMAGE QUALITY METRICS

Quality metrics are used to estimate the deterioration of knowledge when image fusion is to be achieved. If the source picture is present, then fused image and known source image are compared. When source image is not present, the fused image and the input images are compared. The metrics include Mean Square Error (MSE), Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR), Mean, Standard Deviation (SD), Average Difference (AD), Structure Content (SC), Maximum Difference (MD), Mean, Entropy, Normalized Absolute Error (NAE) and Normalized Cross Correlation (NCC).

V. RESULTS

The results for fusion technique are obtained using MATLAB2013a software. The fusion results using DWT, DSWT, hybrid techniques are shown below and the values are compared.

A. Results for CT and MRI images.

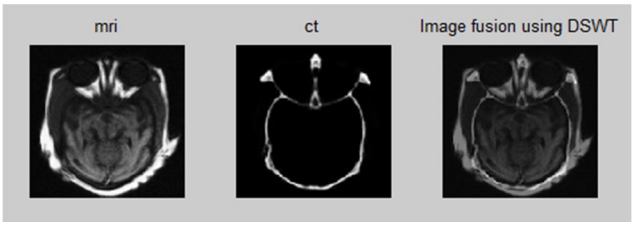

Fig. 5. Image fusion using DSWT with CT and MRI images of brain

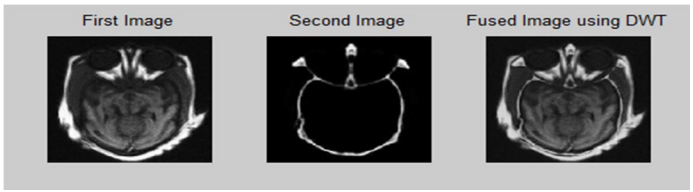

Fig. 6. Image fusion using DWT with CT and MRI images of brain

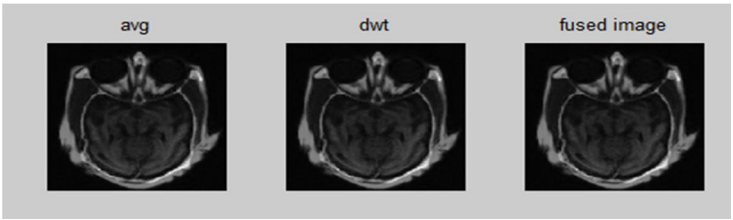

Fig. 7. Hybrid Image fusion using average, DWT and maximum method

The comparison values using different image fusion techniques are shown below and graphs are plotted.

Table 1. Results for fusion techniques.

Method	RMSE	PSNR	Entropy	Mean	NAE	AD	MD	NCC	SD	SC
Minimum	75.7899	24.2660	1.9035	4.6843	0.9118	50.3713	255	0.0715	17.3871	18.9535
Average	40.0056	37.0449	5.9227	31.9410	0.5043	22.5144	127.500	0.5536	34.7875	2.7725
Maximum	25.6452	45.9382	6.8781	59.5527	0.0967	5.3426	0	1.0357	61.3302	0.8507
DSWT	40.2914	36.9025	5.9531	31.7139	0.5086	22.5144	136.7066	0.5543	35.2542	2.7343
DWT	25.6250	45.9739	6.8538	59.4752	0.1229	5.2543	70.9469	1.0339	61.4455	0.8534

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Table 2. Comparison values for hybrid fusion techniques.

Method	RMSE	PSNR	Entropy	Mean	NAE	AD	MD	NCC	SD	SC
Average-DWT-Maximum	0	infinity	5.9224	30.9412	0	0	0	1	34.7873	1

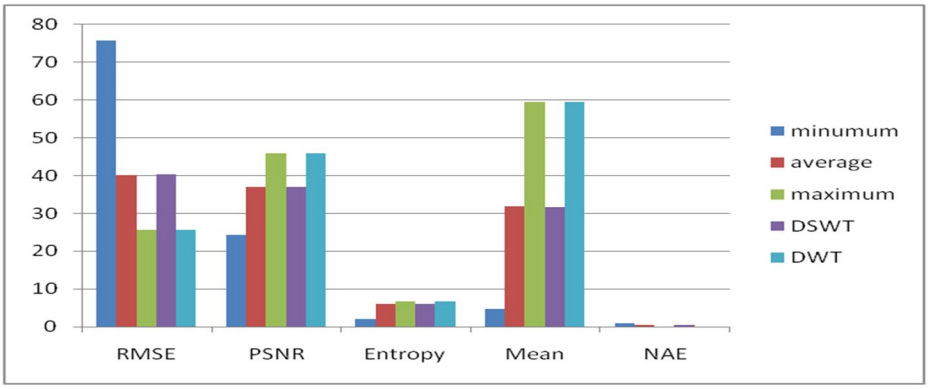

Fig.8a.Graph plot for RMSE, PSNR, Entropy, Mean, NAE

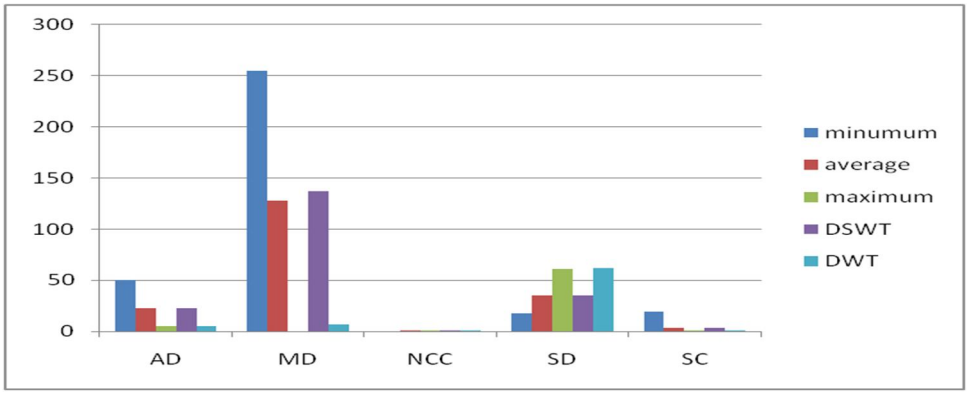

Fig. 8b.Graph plot for AD, MD, NCC, SD, SC

VI. CONCLUSION

As we know that if the fused image with high PSNR, entropy, low RMSE value, low NAE and NCC value equal to one then the fusion technique is the best method. In normal Fusion techniques like DWT, DSWT value of PSNR is low. In order to increase the value of PSNR a Hybrid Fusion technique is proposed which further increases the value of PSNR to infinity and reduce the value of NAE to zero. By using this hybrid technique in medical applications the diagnosis required for the effected patient can be easily identified and proper treatment can be suggested.

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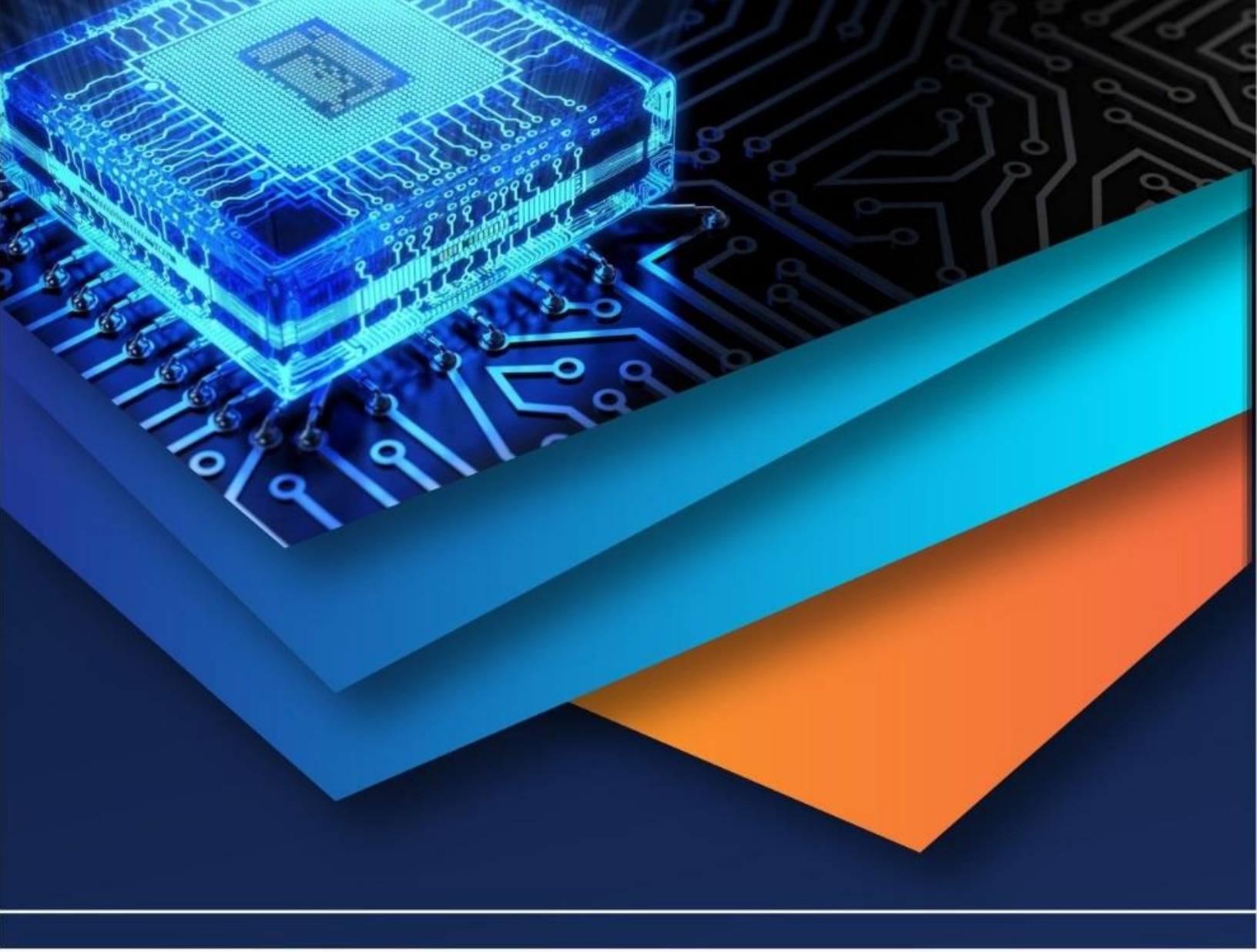

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