Fusion of MRI and CT Images with Double Density Dual Tree Discrete Wavelet Transform

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Abstract— **Data fusion technique is a powerful tool for extracting higher quality information from large amount of remote sensing images or various types of medical images and eliminating redundancy among these images. Traditional multi-resolution analysis image fusion methods always decompose multi-temporal images into low and high frequency parts, then fuse the low frequency part of each image into one low frequency part and do not deal with fusion of high frequency parts which represent image' details, such as edges, corners and ridges. In this paper, the fusion of the CT image which gives the information about boundary of the affected area and MR image which gives the information about the tissues affected by diseases is considered and the resultant image provides all boundary and internal details for diagnostic purpose. Entropy based analysis is done on fused CT and MR images using lifting wavelet and double density dual tree DWT**

Keywords - MRI; CT; fusion; wavelet; entropy

I. INTRODUCTION)

Image fusion is the procedure of extracting important visual information from images and merging them to create new image. Image fusion is vital in many fields like medical imaging, remote sensing and satellite imaging. Data fusion is subdivided into three levels which are pixel-level fusion. feature-level fusion and decision-level fusion. The different types of image fusion are nonlinear methods, linear superposition, artificial neural networks, optimization approaches, wavelet transform, image pyramids and generic multi-resolution fusion scheme.

The main purpose of medical imaging is to attain high resolution image with more details for efficient diagnosis. MR and CT imaging provides special complicated features of the organ to be imaged. So, the fusion of MR and CT image of same organ would provide better details. The paper is organized as follows: section 2 provides literature survey, section 3 the proposed image fusion model, section 4 the experimental results and section 5 the performance evaluation and section 6 the conclusions.

II. LITERATURE SURVEY

Many image fusion methods have been proposed in the field using wavelet based techniques [1]. Here a novel algorithm base on lifting transform has been proposed. The fused image is suitable for human vision characteristic and has more advantages for further analysis, understanding and recognition. Image fusions based on Double Density Dual Tree DWT functions have been highly[2] useful in many applications such as medical image fusion and merging out-of-focus images.

In the multiscale analysis, discrete wavelet frame transform and fuzzy region feature fusion scheme [4] is performed for the selection of source image wavelet coefficients. The first step is to choose an image as object image that can reflect the object and background The third step is defining the attribute of the regions by some region features, for example, the mean of gray level in a region. In that case, each pixel point has its value of membership. Then using certain attribute region fusion scheme, the multiscale representation of the fusion result is achieved by defuzzification process. The final step performs the inverse discrete wavelet frame transform and the final fusion result is obtained. In [3] a novel algorithm is proposed for fusion of medical images.

III. Proposed Image Fusion Model

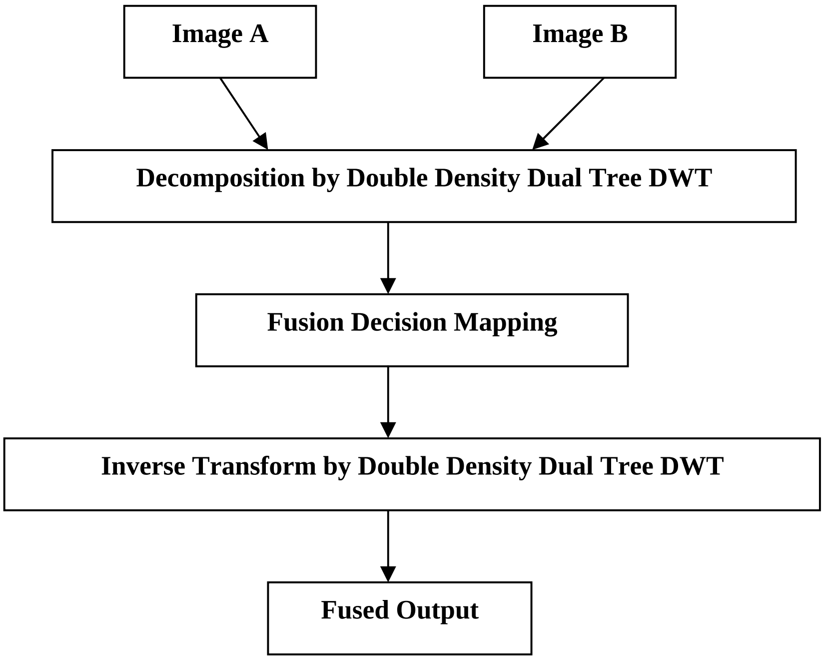

Fig 1.System Design of the proposed image fusion model

Figure 1 represents the block design of proposed image fusion model. Here both CT and MR images are taken as input and then each image go through various processes and then finally produce the fused image with high entropy values as output. The block design shows how these two images are decomposed and then the decomposed wavelet coefficients of these two images are fused by applying the fusion algorithm (Maximum selection scheme, Minimum selection scheme, Average operator selection scheme, etc) and then the fused image with high entropy value is found as shown in fig 2.

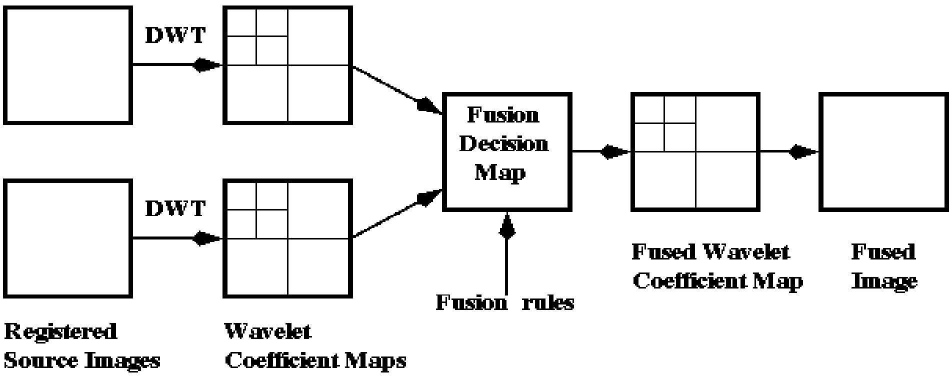

Fig 2 Block diagram for Image Fusion Process

The registered source images of CT and MRI are decomposed and then each wavelet coefficient is stored in an fusion decision mapping as an array. Then each coefficient is compared by applying the fusion algorithm to obtain the fused image as an output with high entropy value.

IV. Experimental Results

The experiment is simulated with MATLAB using first by using lifting wavelet transform and then with Double Density Dual Tree Discrete Wavelet Transform (3DT-DWT). The 2-D transform for carrying out lifting wavelet transform is given below: Decomposition of two different images (CT and MRI image as in Figure 3) into low frequency and high frequency component by using lifting wavelet transform results in Fusion Decision Mapping(FDM).

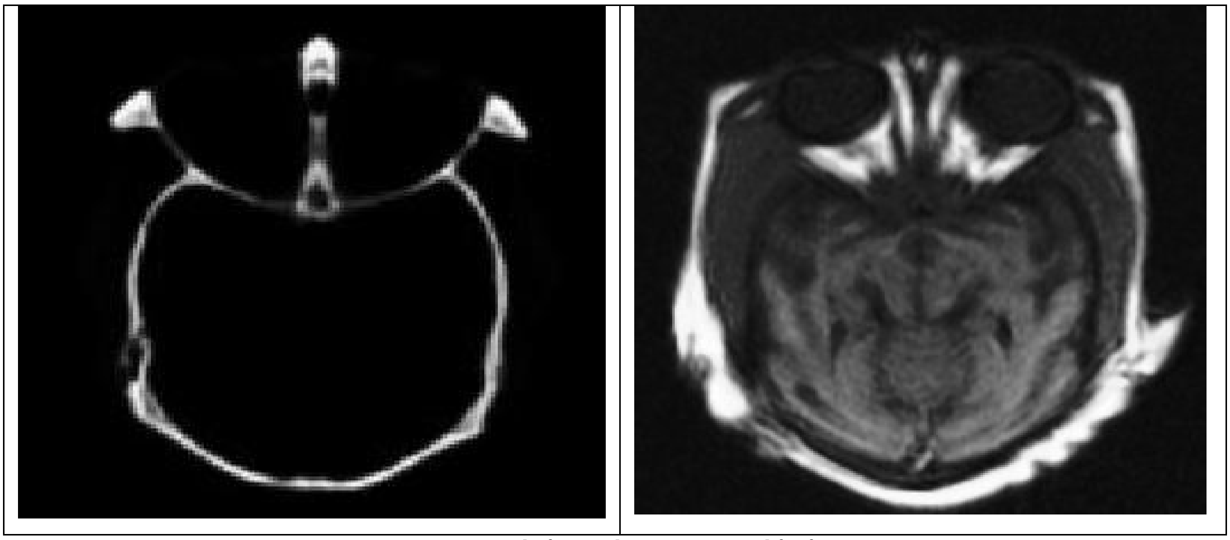

Figure 3 Original of CT and MR Images used for fusion

Decomposed wavelet coefficients of the CT and MR images are compared and then the low frequency coefficient and high frequency coefficient are fused using maximum selection scheme fusion rule. Finally the fused low frequency and high frequency coefficient are reconstructed into fused image by applying inverse lifting wavelet transform and figure 4 shows the reconstructed image.

3DT-DWT undergoes different phases to produce better results than lifting wavelet transform .It undergoes different orientation at different phases which produces better image fusion when compared to lifting transform The first step is the decomposition process is done by analysis filter bank and the real and imaginary parts of wavelet coefficient is produced as output.

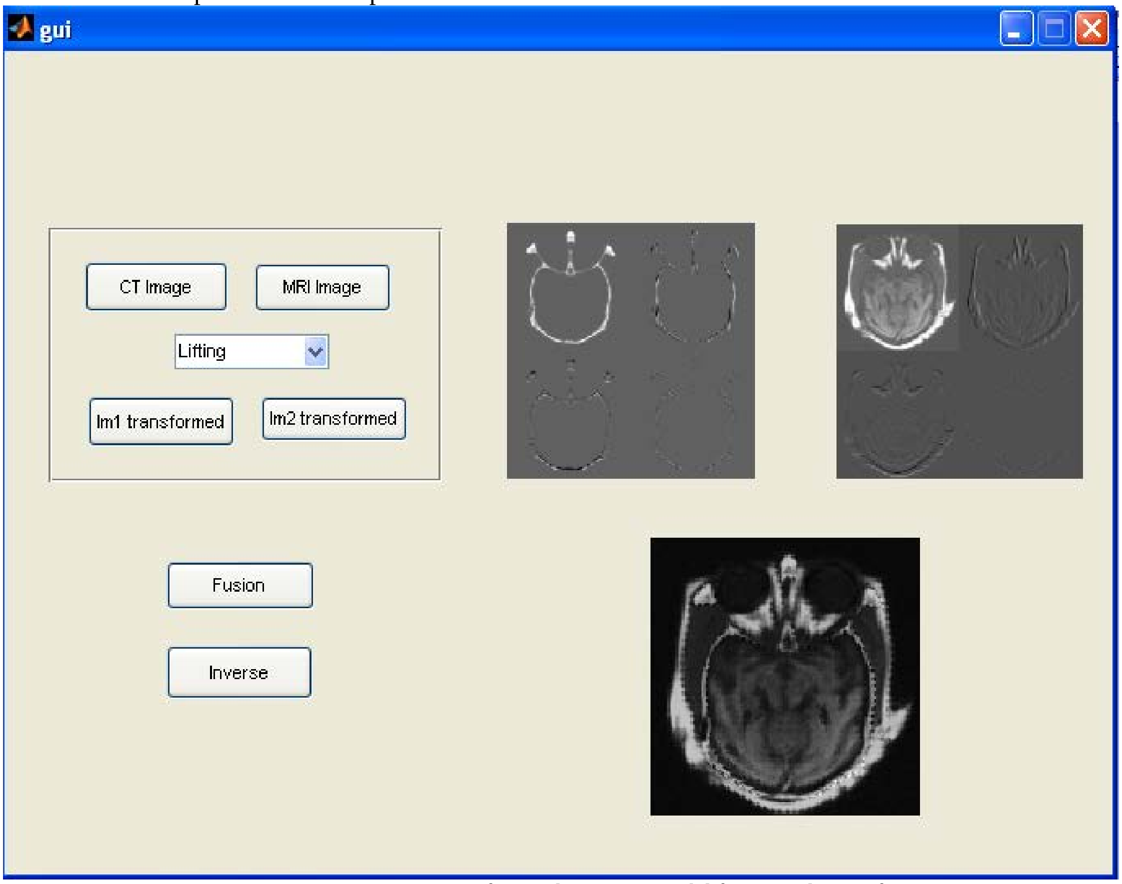

Figure 4 Image Reconstruction of CT and MR image with lifting wavelet transform

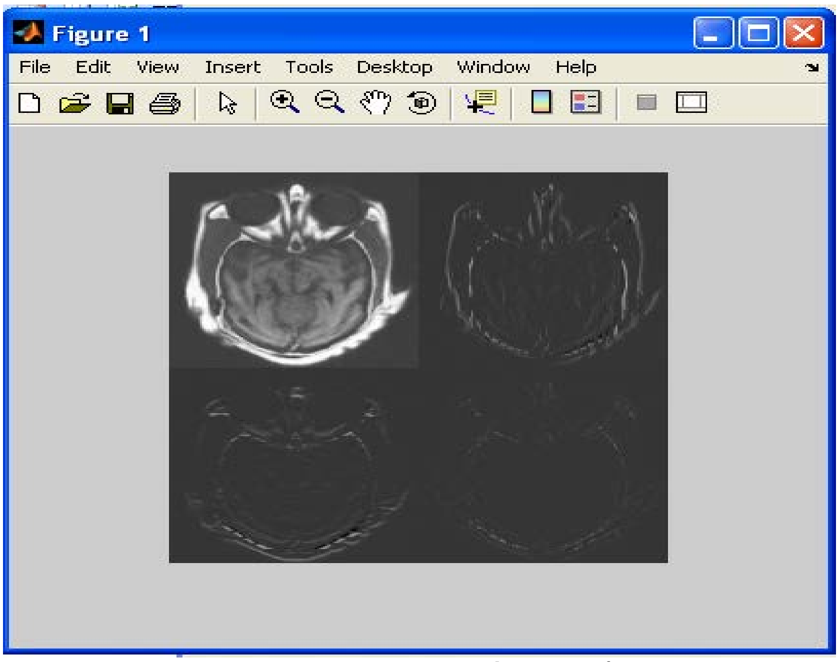

Figure 5 Fusion Decision Mapping in CT and MR Image for 3DT-DWT

The decomposed wavelet coefficient of the CT and MR images are compared and then the low frequency coefficients are fused by average operator scheme and high frequency coefficients by maximum selection scheme and the remaining sub bands are fused by standard deviation selection scheme. Decomposed wavelet coefficients of CT and MR images are compared (the size of the two images will have 256×256 matrix form) and fused image will have double value for pixel. The entropy value will be calculated by taking the occurrence of pixel value and fusion decision mapping is shown in figure 5. The image reconstruction is obtained by applying the inverse 3DT-DWT as in figure 6.

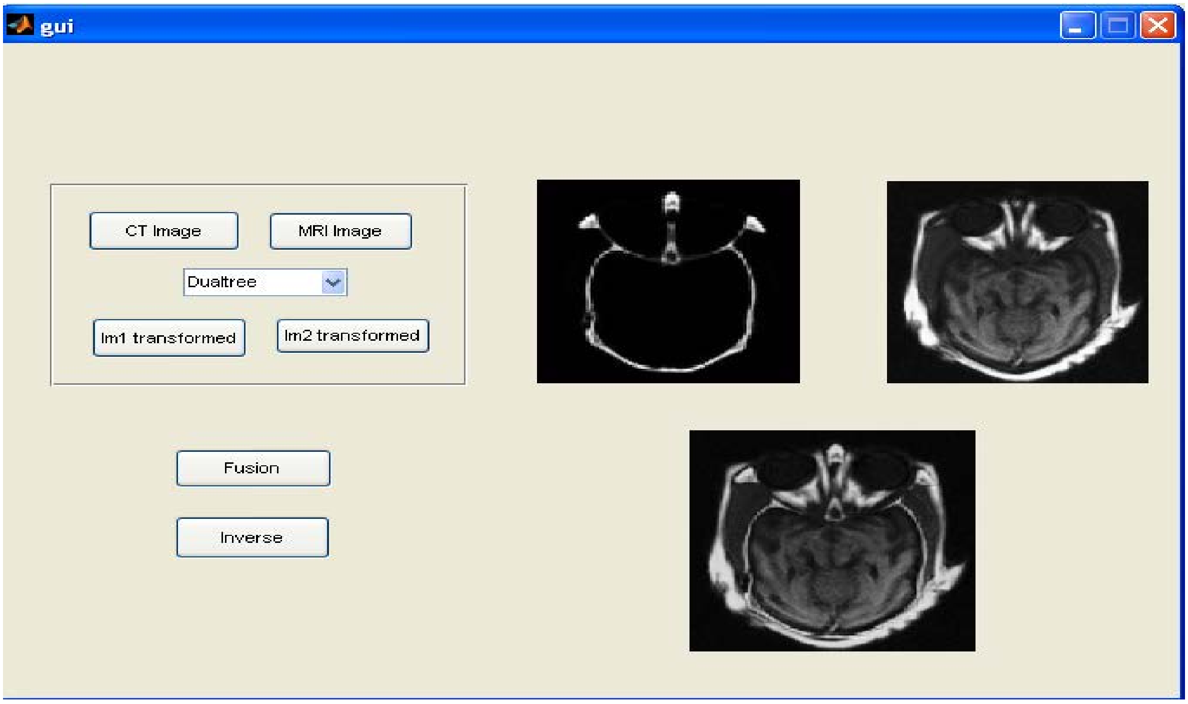

Figure 6 Image Reconstruction in CT and MR Image for 3DT-DWT

V. Performance Evaluation of Image Fusion

Common metrics to evaluate the results of fusion process are information entropy and Root Mean Square Error(RMSE).A digital image contains pixels which has rows and columns.. For an image having L grey levels, the entropy is:

$$H = -\sum_{i=1}^{L} P(i) \log_2 P(i) \tag{1}$$

The RMSE between the reference image, *I* and the fused image F is defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[I(i,j)-F(i,j)]^2}{N.M}} \tag{2}$$

where and *i j* denotes the spatial position of pixels, *M* the dimensions of the images. *N*. The experimental results obtained are analyzed with entropy only.

Decomposed wavelet coefficients of CT and MR images are compared (the size of the two images 256×256) and it produces integer value for fused image. The entropy value will be calculated by taking the occurrence of pixel value (integer value) and applying in the formula(1). Both the image fusion algorithms (lifting wavelet transform and 3DT-DWT) are compared based on entropy value and it is found that 3DT-DWT provides high information entropy value for better diagnostic purpose as in Table 1.

Table 1 Comparison of Entropy Value

Algorithms	**Entropy Value**
Lifting Wavelet Transform	6.7
Double Density Dual Tree DWT	16

The graphical plot of occurrence of pixel value against entropy value is provided in figure 7

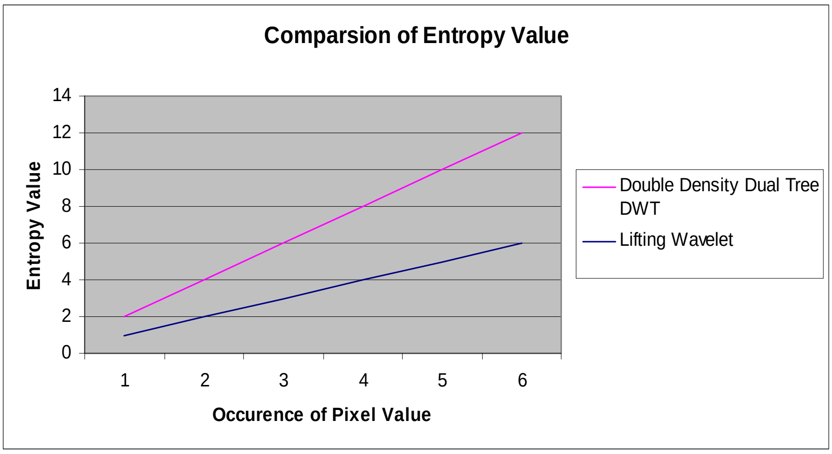

Figure 7 Comparison of Entropy Value

VI CONCLUSIONS

An innovative and cost effective system has been designed for medical image fusion with wavelet transform techniques. Medical image fusion provides high resolution image for diagnostic purpose. In this paper the images are fused effectively and analyzed by lifting wavelet transform and Double Density Dual Tree DWT. Finally the high entropy value for better image fusion has been evaluated for both the methods and it is concluded that 3DT-DWT provides better result. The future work will focus on refining the fusion algorithm for better resolution and test different modality images like PET, MRI etc.

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