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ROBUST IMAGE FUSION USNG SINGLE LEVEL DWT AND SSIM

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ABSTRACT— Image fusion is processes of combining complementary information from a set of input images.The resultant fused image give large and reliable information.In this project we use Single Level Discrete Wavelet Transform (DWT) to combine two medical images (CT scan and a MRI) from a single or multiple imaging modalities to improve the imaging quality,reduce randomness and redundancy in order to increase the clinical applicability of medical images for diagnosis and assessment of medical problems.The main aim is to increase the likelihood of the final image to both the original images and this similarity index is measured using SSIM (Structural Similarity Index), it is used as an quality measure of one of the image is regarded as of perfect quality.

INDEX TERMS— Image Fusion, Sinlge Level Discrete Wavelet Transform, SSIM.

1. INTRODUCTION

Image fusion refers to the techniques that integrate complementary information from multiple image sensor data such that the new images are more suitable for the purpose of human visual perception and the computer processing tasks. The fused image should have more complete information which is more useful for human or machine perception.

The advantages of image fusion are:

(1) Improving reliability
(2) Capability.
(3) Improve the quality and increase the application of these data.
(4) Image fusion techniques allow the integration of different information sources.

Many fusion techniques have been proposed in the literature. Use of the simplest image fusion technique like pixel averaging will not recover well fused image due to reduced contrast effect. Other methods based on Intensity Hue Saturation (IHS), Principal Component Analysis (PCA) etc. has also been developed.IR sensor will make complement of image information with visible image range. Visible images offer a rich content where a detection of people object can now ever be limited by change in lighting conditions.

In this project we do fusion using Single Level Discrete Wavelet Transform (DWT).In this paper a novel approach for fusion of different medical images of MRI and CT has been proposed using discrete wavelet transform. The CT and MRI of the same person and same spatial parts have been used for analysis and different fusion rules have been implemented on them.

2. DISCRETE WAVELET TRANSFORM

Wavelet theory is an extension of Fourier theory and it is introduced as an alternative to the short time Fourier transform. In Fourier theory the signal is decomposed into sines and cosines but in wavelets the signal is projected on a set of wavelet functions. Fourier transform would provide good resolution in frequency domain but wavelet would provide good resolution in frequency domain as well as time domain.

Wavelet transforms are linear transforms whose basis functions are called wavelets. The wavelets used in image fusion can be classified into many categories such as:-

(a) Orthogonal
(b) Bi-orthogonal etc.

Although these wavelets share some common properties, each wavelet has a unique image decompression and reconstruction characteristics that lead different fusion results.

The Discrete Wavelet Transform (DWT) of image signals produces a non-redundant image representation, which provides better spatial and spectral localization of image information, compared with other multi scale representations. Recently, Discrete Wavelet Transform has attracted more and more interest in image processing. The DWT can be interpreted as signal decomposition in a set of independent, spatially oriented frequency channels.

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The signal S is passed through two complementary filters and emerges as two signals, approximation and Details. This is called decomposition or analysis. The components can be assembled back into the original signal without loss of information. This process is called reconstruction or synthesis. The mathematical manipulation, which implies analysis and synthesis, is called discrete wavelet transform (DWT) and inverse discrete wavelet transform (IDWT).

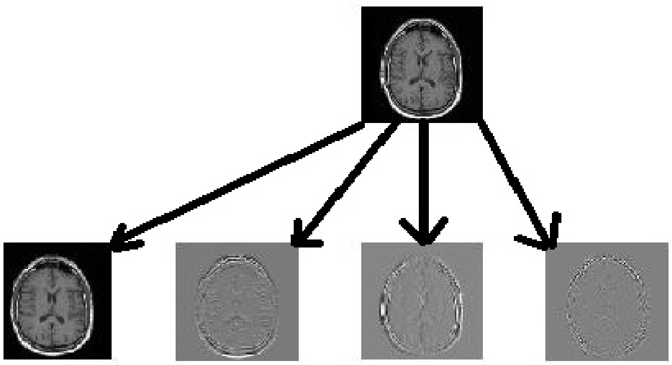
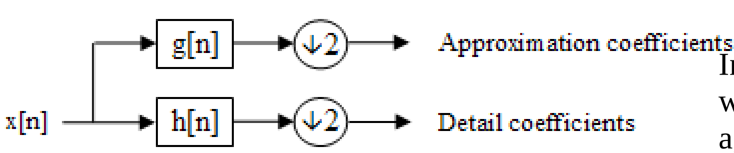


FIG: USING DWT (DISCRETE WAVELET TRANSFORM)

The DWT of a signal $x$is calculated by passing it through a series of filters. First the samples are passed through low pass filter with impulse response resulting in a convolution the two:

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k]$$

The signal is also decomposed simultaneously using a high pass filter h. The outputs giving the detail coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as quadrature mirror filter



Block diagram of filter analysis

However, since half the frequencies of the signal have now been removed, half the samples can be discarded according to Nyquist's rule. The filter outputs are then subsampled by 2. In the next two formulas, the notation is the opposite: g- denotes high pass and h- low pass as is Mallat's and the common notation:

$$y_{\mathrm{low}}[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k]$$

$$y_{\mathrm{high}}[n] = \sum_{k=-\infty} x[k]g[2n-k]$$

This decomposition has halved the time resolution since only half of each filter output characterises the signal. However, each output has half the frequency band of the input so the frequency resolution has been doubled.

With the subsampling operator $\downarrow$

$$(y \downarrow k)[n] = y[kn]$$

The above summation can be written more concisely.

$$y_{\mathrm{low}} = (x * g) \downarrow 2$$
$$y_{\mathrm{high}} = (x * h) \downarrow 2$$

However computing a complete convolution $x * g$with subsequent down sampling would waste computation time.

The lifting scheme is an optimization where these two computations are interleaved.

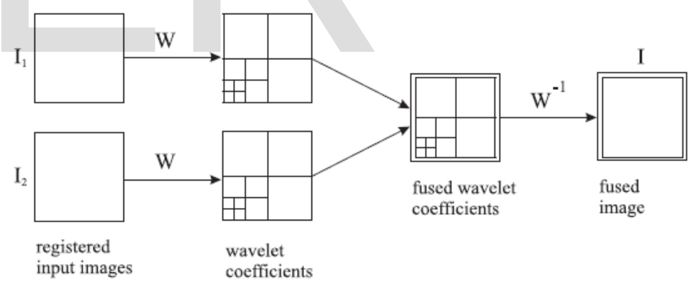


Image Fusion using discrete wavelet transform

In all wavelet based image fusion techniques the wavelet transforms W of the two registered input images I1(x,y) and I2(x,y) are computed and these transforms are combined using some kind of fusion rule Ø. This is given by equation below:

$I(x,y)=W-1$ (Ø (W ($I1$ x,y)) ,W($I2$ x,y)))

Where W-1 is the inverse discrete wavelet transform (IDWT). In general, the basic idea of image fusion based on wavelet transform is to perform a multiresolution decomposition on each source image; the coefficients of both the low-frequency band and high-

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frequency bands are then performed with a certain fusion rule. After that, the fused image is obtained by performing the inverse DWT (IDWT) for the corresponding combined wavelet coefficients.

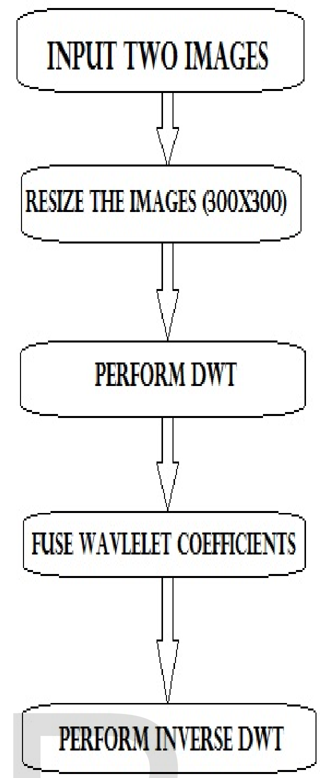
3. Algorithm

Following algorithm has been developed and implemented in MATLAB software.
Steps are:

- First we read the two images (CT scan and MRI).
- Resize both the images to 300x300.
- Convert both images to grayscale using rgbtogray.The resultant images are the ones on which the process of DWT is to be done.
- Perform single level discrete wavelet transform on the resultant sub-images.
- Let the sub images be ca, ch, cv, cd and ca1, ch1, cv1, cd1.
- Now we fuse together ca with ca1 and similarly also the others using DWTah method.
- After the fusion we get 4 images of qualities of both the original source images.
- Generate a final matrix of fused wavelet coefficients.
- Compute the inverse discrete wavelet transform to get the final fused image.
- Finally compute the SSIM to measure the similarity of the final fused image with that of the two original source images.
- Also, compute and compare the processing time by each method.

4. Flowchart

The two input images are first read and converted to indexed images. After that the wavelet decomposition is done to find the approximate, horizontal, vertical and diagonal details. The decomposition level and the type of wavelet used are specified. DWT is then performed on the input images. The coefficients found are then fused used a specific fusion rule and then the images are restored back using inverse discrete wavelet transform.



5. Fusion Techniques

Image fusion techniques are gradually increasing as a potential means of combining two (or more) images for maximizing information content of the resultant image. Image fusion techniques usually used for image processing where a single image sensor is not enough to provide required data. So, fusion is adopted where direct object perception is difficult and noise prone or expensive.

Medical Image Fusion algorithms and devices have shown notable achievements in improving clinical accuracy of decisions based on medical images. It is practically impossible to capture all the details from one imaging modality that would ensure clinical accuracy and robustness of the analysis and resulting diagnosis.

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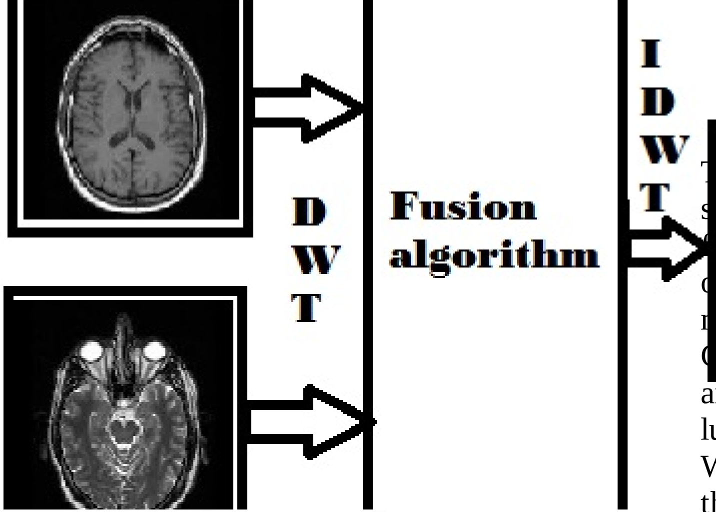


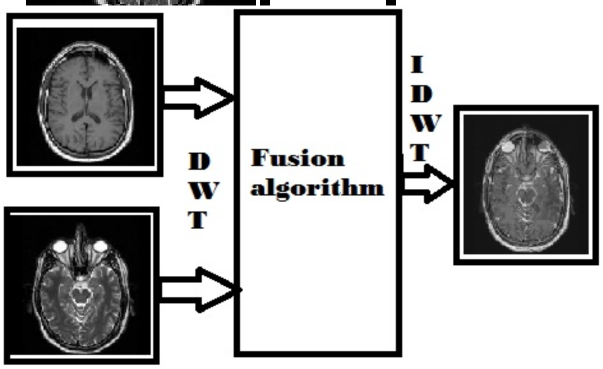


Fig-2: Framework of DWT based image fusion algorithm

DWTah:

The lowest AC components including DC coefficients are averaged and the remaining AC coefficients are chosen based on largest magnitude.

$$x_f(l_1,l_2) = 0.5x_1(l_1,l_2) + x_2(l_1,l_2)\text{...........(1)}$$

where

$$l_1, l_2 = 0,1,2,....,0.5N - 1$$

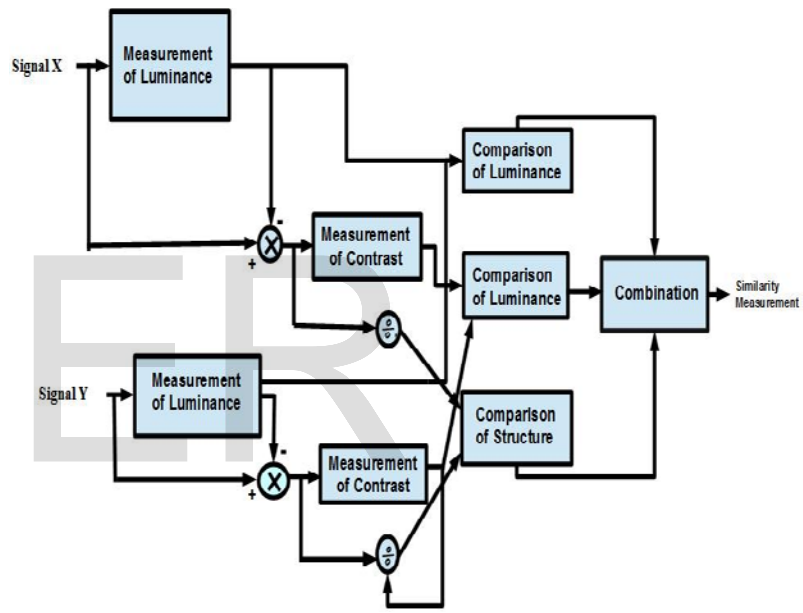
$$X_f(l_1,l_2) = \begin{cases} X_1(l_1,l_2) & |X_1(l_1,l_2)| \geq |X_2(l_1,l_2)| \\ X_2(l_1,l_2) & |X_1(l_1,l_2)| < |X_2(l_1,l_2)| \end{cases} \}$$

Where $l_1, l_2 = 0.5N, 0.5+1, 0.5N+2, ...N-1$

6. SSIM

SSIM is Structural Similarity Index, it is a method for measuring the similarity between two images. The SSIM index can be viewed as a quality measure of one of the images being compared, provided the other image is regarded as of perfect quality.

The luminance of the surface of an object being observed is the product of the illumination and the reflectance, but the structures
of the objects in the scene are independent of the illumination.
Consequently, to explore the structural information in an image, we wish to separate the influence of the illumination.
We define the structural information in an image as those attributes that represent the structure of objects in the scene, independent of the average luminance and contrast. Since luminanceand contrast can vary across a scene, we use the local luminance and contrast for our definition.



SSIM measurement system

7. Results

In this project we use DWT to perform Image fusion and we get a result of the

Following percentages:-

MSSIM (comparison of 1st image with the result) = 98.13%

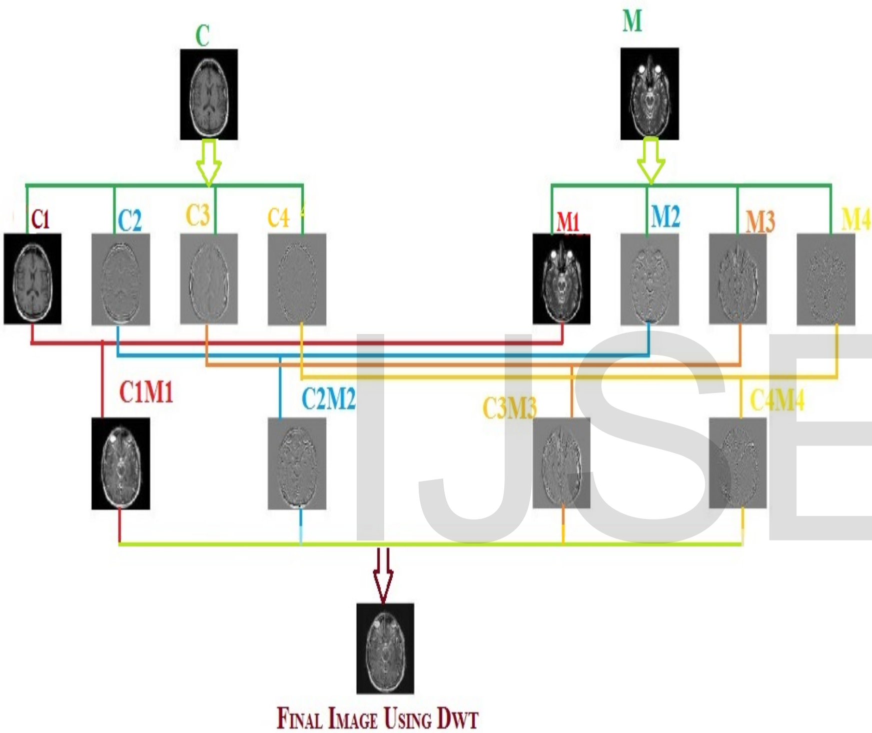
MSSIM1 (comparison of 2nd image with the result) = 97.44%

Earlier, Image fusion have been done by many other approaches and mothods namely PCA, DCT, Pixel based fusion.

- Using Pixel based fuson we get a get a result in the range 84-92%

- Also DWT using PNSR and MSE also gives promising results but generally below 50%
- Using DCT and PCA we get a result in the range 80-90%

Thus, we can visualize effectively the difference in the result obtained using DWT and other methods.



8. Conclusion

From the above results, it is clear that DWT provides a better result in fusing two images into one.Moreover, We can safely say that DWT is the best method for image fusion when high quality and precision of the fused image is in question.

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