

DTCWT based Fusion Technique for Medical Image Super Resolution

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ABSTRACT:Image Fusion in image processing means combining of the multiple input images to get superior image. To increase the quality of the input images Image Fusion Techniques are used. The input images must be the images of the same picture with different quality measures. The quality of the output image will be better than any of the input images. The main methods of the image fusion involve simple image fusion, pyramid based image fusion and wavelet based image fusion. Image fusion methods can be used in areas of medical imaging, remote sensing, entertainment etc. Image fusion mechanism for improving the image quality of medical images using dual tree complex wavelet transform and NLM filter has been presented.

KEYWORDS:Text Image Fusion, Wavelet based technique, Dual tree complex wavelet transform, shift invariance, multiresolution analysis..

I. INTRODUCTION

In computer vision, Multisensory Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. In remote sensing applications, the increasing availability of space borne sensors gives a motivation for different image fusion algorithms. Several situations in image processing require high spatial and high spectral resolution in a single image. Most of the available equipment is not capable of providing such data convincingly. Image fusion techniques allow the integration of different information sources. The fused image can have complementary spatial and spectral resolution characteristics. However, the standard image fusion techniques can distort the spectral information of the multispectral data while merging.

Image processing is having great importance in the field of remote sensing, medical imaging, entertainment etc. Image Fusion is one of the important technique in image processing. In image fusion technique multiple input images are combined together to create output image of superior quality. An image can be represented both in spatial domain and in spectral domain. Image Fusion [1] is the process of fusing perfectly registered input images which can represent both spatial and spectral information. It retains important information and produces an image which is better for human and computer perception for further processing. Since spatial representation is simple, spatial fusion methods are also simple. Spectral representation can clearly define the edge features of the image. So the spectral based image fusion methods produce better quality output image rather than spatial methods. Simple Image Fusion methods come under the category of spatial methods whereas Pyramid as well as Wavelet transform methods come under spectral methods.

Many methods exist to perform image fusion. The very basic one is the high pass filtering technique. Later techniques are based on Discrete Wavelet Transform, uniform rational filter bank, and Laplacian pyramid. Multi-sensor data fusion has become a discipline which demands more general formal solutions to a number of application cases. Several situations in image processing require both high spatial and high spectral information in a single image. This is important in remote sensing. However, the instruments are not capable of providing such information either by design or because of observational constraints. One possible solution for this is data fusion.

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Image fusion methods can be broadly classified into two groups - spatial domain fusion and transform domain fusion. The fusion methods such as averaging, Brovey method, principal component analysis (PCA) and IHS based methods fall under spatial domain approaches. Another important spatial domain fusion method is the high pass filtering based technique. Here the high frequency details are injected into up sampled version of MS images. The disadvantage of spatial domain approaches is that they produce spatial distortion in the fused image. Spectral distortion becomes a negative factor while we go for further processing, such as classification problem. Spatial distortion can be very well handled by frequency domain approaches on image fusion. The multi resolution analysis has become a very useful tool for analyzing remote sensing images. The discrete wavelet transform has become a very useful tool for fusion. Some other fusion methods are also there, such as Laplacian pyramid based, curvelet transform based etc. These methods show a better performance in spatial and spectral quality of the fused image compared to other spatial methods.

The complex wavelet transform (CWT) is a complex-valued extension to the standard discrete wavelet transform (DWT). It is a two-dimensional wavelet transform which provides multiresolution, sparse representation, and useful characterization of the structure of an image. The Dual-tree complex wavelet transform (DTCWT)[3] calculates the complex transform of a signal using two separate DWT decompositions (tree a and tree b). If the filters used in one are specifically designed different from those in the other it is possible for one DWT to produce the real coefficients and the other the imaginary. Dual Tree wavelet transform can be clearly shown in Fig1.

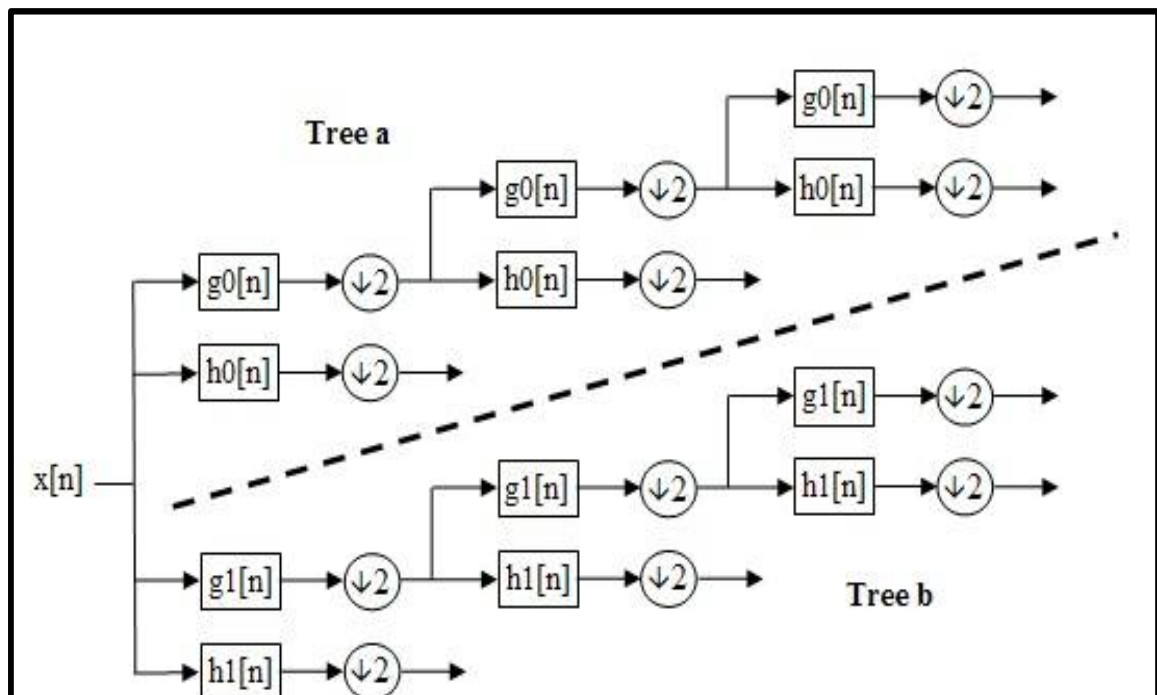


Fig 1: DTCWT Transform

Paper is organized as follows. Section II describes focuses on the different image fusion wavelet based methods evolved so far and their comparison based on the quality of the output image. It also discuss about the different quality metrics that can be used to assess the quality of the output image. Proposed Methodology is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

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II. RELATED WORK

The concept of Dual Tree Complex Wavelet Transform has been first proposed by Prof. Nick Kingsbury [3]. The key advantages of the dual-tree CWT over the DWT are its shift invariance and directional selectivity. This means that the squared magnitude of a given complex wavelet coefficient provides an accurate measure of spectral energy at a particular location in space, scale, and orientation. It also means that CWT-based algorithms will automatically be almost shift invariant, thus reducing many of the artifacts of the critically sampled DWT [3]. Prof Nick Kingsbury explained two properties of Dual Tree CWT viz. Near Shift invariance and Directional Selectivity as follows.

- a) **Near Shift Invariance:** One way to illustrate the near shift invariance of the dual-tree CWT is to observe how the projection of a signal onto a certain scale varies as the signal translates. The projection of a signal onto scale j can be computed by reconstructing the signal from only the wavelet coefficients in subband j . Fig3(a) shows a simple pulse signal $x(n)$ and its reconstruction from the wavelet coefficients at the third scale level of the critically sampled DWT and the dual-tree CWT. Fig3(b) shows the same signal translated by three samples and the corresponding reconstructions from level 3. Comparing Fig3(a), (c), (e) and (b), (d), (f), we see that the DWT-reconstructed signal varies significantly with translations of the signal. However, the CWT-reconstructed signal maintains its shape, illustrating the near shift-invariance of the dual-tree CWT. This property of the CWT greatly simplifies wavelet-based modelling, processing, and other applications.
- b) **Local Hilbert Transform :** The envelope of a real signal can be computed using the Hilbert transform to create a complex-valued analytic signal; the magnitude is the sought envelope. A local Hilbert transform can be computed in the complex wavelet domain simply by multiplying the CWT coefficients by j . As a bonus, the CWT-based local Hilbert transform can be efficiently implemented by a continuously running FB.
- c) **Near Rotation Invariance:** The directionality of the 2-D CWT renders it nearly rotation invariant in addition to nearly shift invariant. Fig2 illustrates the image obtained by reconstruction from only one level of the real DWT and dual-tree CWT for a test image with a sharp edge on a hyperbolic trajectory. The ringing and aliasing artifacts in the DWT coefficients that change with the edge orientation are not present in the CWT coefficients.

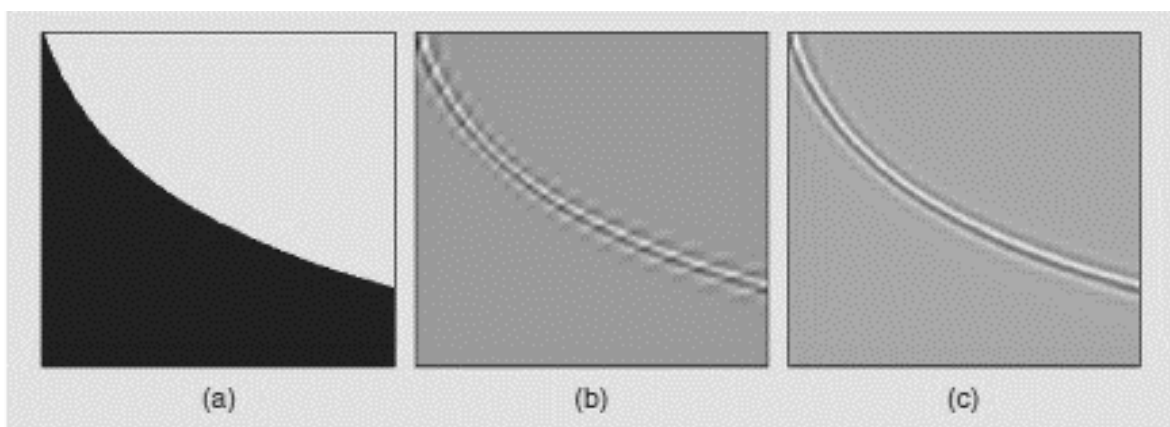


Fig 2 :Near rotation invariance of the CWT. (a) Test image with sharp edge on hyperbolic trajectory. (b) When the test image is reconstructed from one level of the DWT coefficients, ringing and aliasing effects are apparent. (c) The reconstruction of the image from one level of the CWT does not exhibit these phenomena.

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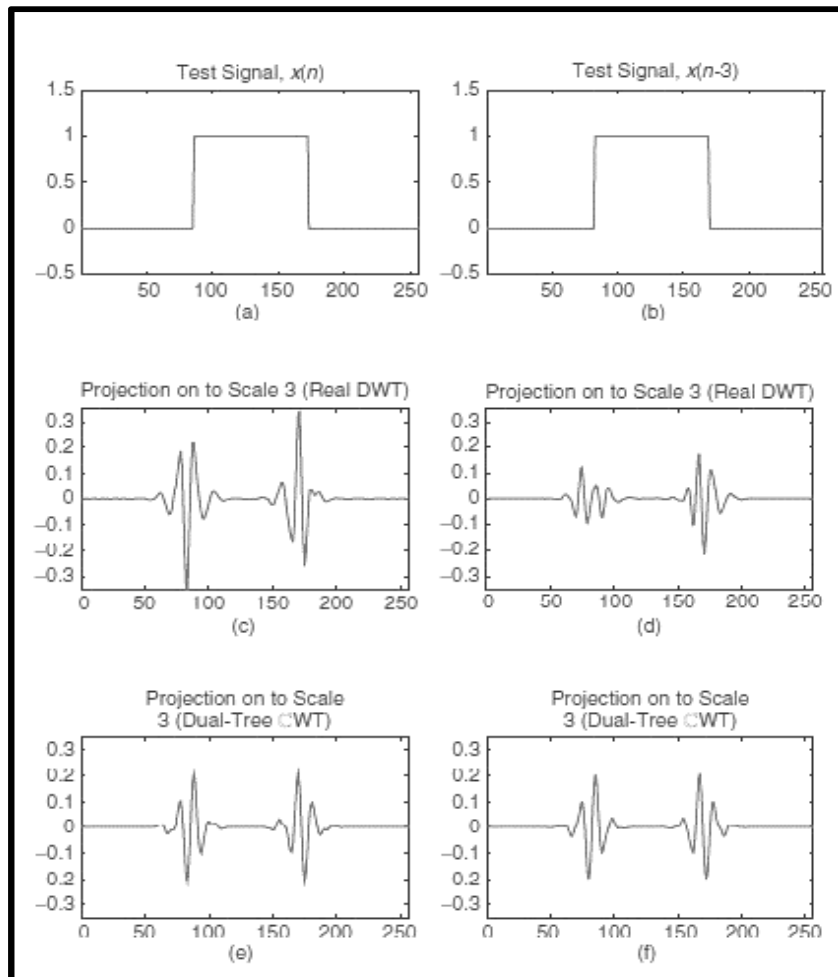


Fig 2:A signal $x(n)$ and its shifted version $x(n - 3)$ (a), (b) and its reconstruction from wavelet coefficients at scale level 3 of the real DWT (c), (d) and dual-tree CWT (e), (f). The CWT is more nearly shift-invariant than the DWT.

CT-DWT given in the above has some disadvantages. This scheme do not having any filtering for noise removal. In the images taken by the camera always contains some noise so due to that noise we will not get correct result. Alexey Lukin, Et. Al [4] given technique for noise removal. Super-resolution algorithm produces even sharper images and the high-frequency component of noise is typically amplified. However the process of regularization helps preventing noise amplification by minimizing the total variation of the resulting image. If the strength of regularization (value of α) is increased, the noise is suppressed, while the sharpness of image contours is preserved.

In the [6] along with CT-DWT another two types of filtering has been used viz. Lanczos Interpolation and Non Mean Filtering (NML) to achieve super resolution. The Non-Local Means Filter[6] is built up on the concept that the image characteristics are likely to appear itself within some neighborhood of the image. The denoising is aimed at removing the noise and preserving the image details. The NL means filter is an extension of the neighborhood filtering algorithm. The NL-means filter computes the denoised pixel by the weighted sum of the surrounding pixels. The commonly used interpolation techniques are based on nearest neighbors (include nearest neighbor, bilinear, bicubic, and Lanczos). Lanczos resampling[6], invented by Cornelius Lanczos, is an interpolation function that is used

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extensively in the arena of digital signal processing. It is basically a Fourier kernel. Its essentiality is for smoothly interpolating the value of a digital signal between its samples.

Though DTCWT is a complex wavelet transform, but the filters that it uses are all real valued. So, no complex computation is involved in its implementation, making it computationally efficient. In 2-dimension, DTCWT is achieved by applying filters separately along rows and columns. Hence Richa Srivastava et. Al[8] has been proposed “Threshold based Image Fusion in Dual Tree Complex Wavelet Domain”. Wavelet based thresholding is the most popular tool for reducing noise present in the images. In thresholding, they compare the values of wavelet coefficients with the threshold value and preserve them if their absolute values are greater than the predefined threshold. In this work, they have utilized this concept in image fusion. In denoising, they discard the coefficients having lower absolute values than the threshold, because the noise affects the small value wavelet coefficients substantially than the high value wavelet coefficients. In the same way, in image fusion, they are choosing wavelet coefficients having high absolute values. Therefore, they select the wavelet coefficient whose absolute difference from the threshold is higher. The threshold can be defined in two ways. Either it is fixed and constant for the whole processing or it may vary depending on particular parameter(s). Varying threshold is more efficient than the fixed threshold because in multiresolution analysis an image is divided into coefficients of different frequencies and fixed threshold is not able to handle coefficients of different frequencies properly.

III. PROPOSED ALGORITHM

The image super resolution for the input low resolution medical image using the newly introduced DTCWT based image fusion technique using the NLM filtering has been introduced. The DTCWT is used to decompose the input low resolution images into different frequency sub bands which are then process to get super resolution image.

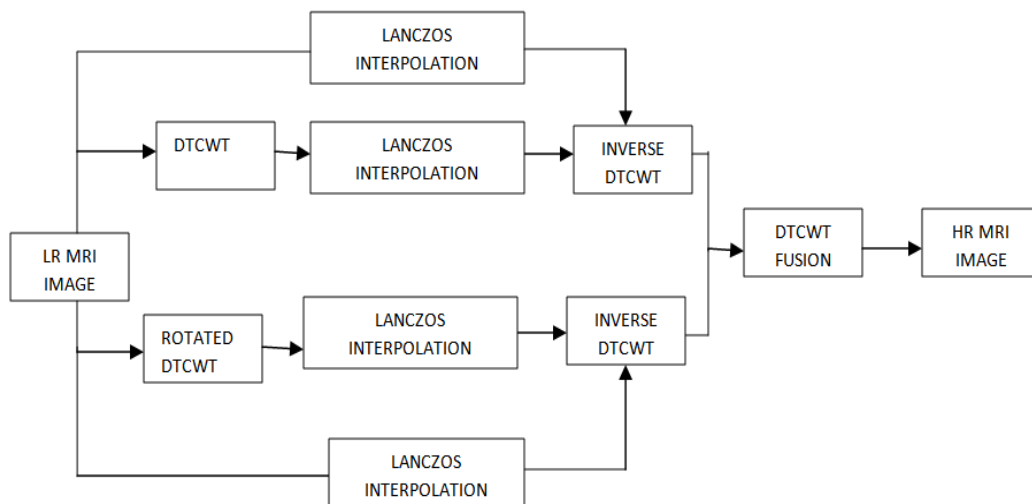


Fig 3: Proposed Methodology

In this proposed algorithm, the input low resolution image applied is Medical image (MRI) of different sizes (128 and 256). The DTCWT and Rotational DTCWT are used to decompose the LR image into its different frequency sub bands. For the normal DTCWT, the LR image is decompose into 16 sub bands out of which 12 sub bands are HF sub bands and 4 sub bands are LF sub bands. The 12 sub bands which are having more information contents are used for

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the proposed application. Similarly for Rotational DTCWT, the 16 sub bands are generated. These sub bands thus produced has the angle of inclination of 45 degree to that of sub bands generated from normal DTCWT.

The 12 HF sub bands are interpolated by using lanczos interpolation. After interpolation process, the processed 12 sub bands and interpolated 4 sub bands from input LR image which are interpolated by $\beta/2$ are combined by inverse DTCWT and rotational DTCWT on both sides.

Thus the interpolated outputs from normal and rotational DTCWT are combined by fusion technique using once again DTCWT. The final output of the proposed method is super resolution image.

IV. EXPERIMENTAL RESULTS

A) Figures DTCWT and Rotational DTCWT Results.

The following results are depicted from above proposed algorithm.

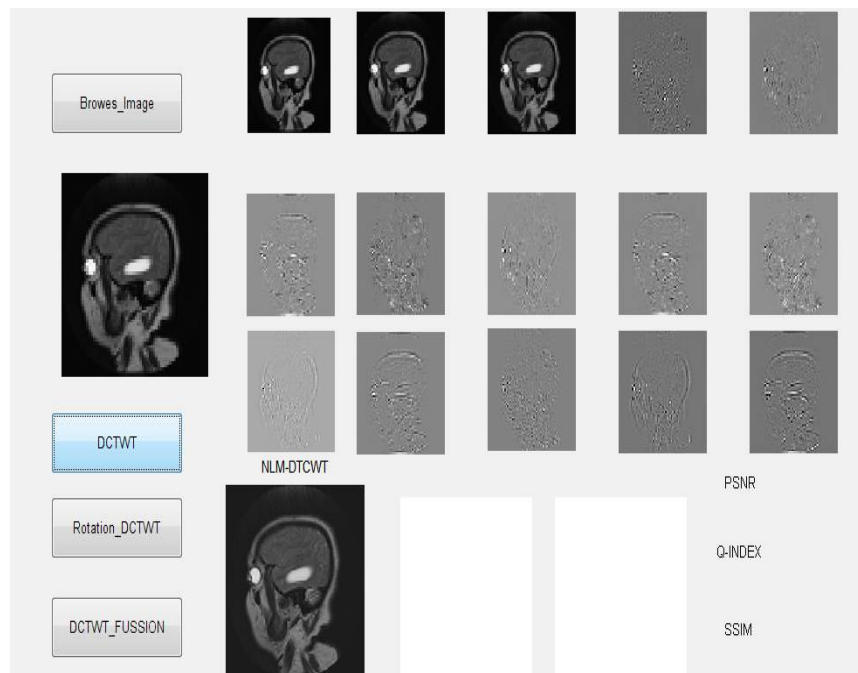


Fig 4:DCTWT

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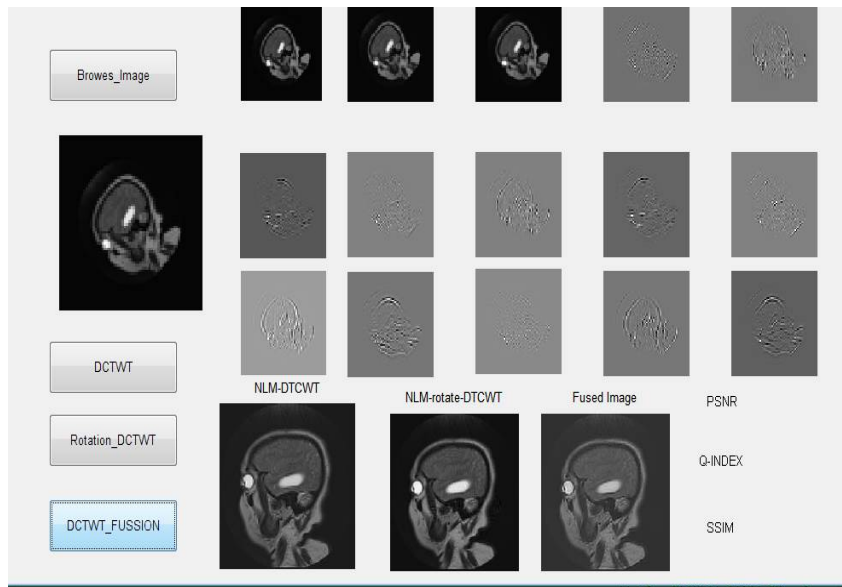
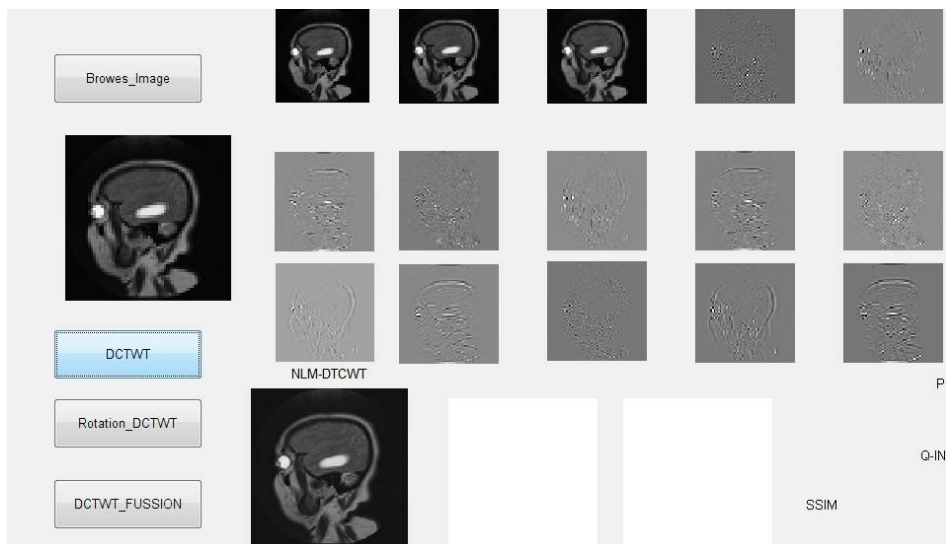


Fig 5: Rotational DTCWT

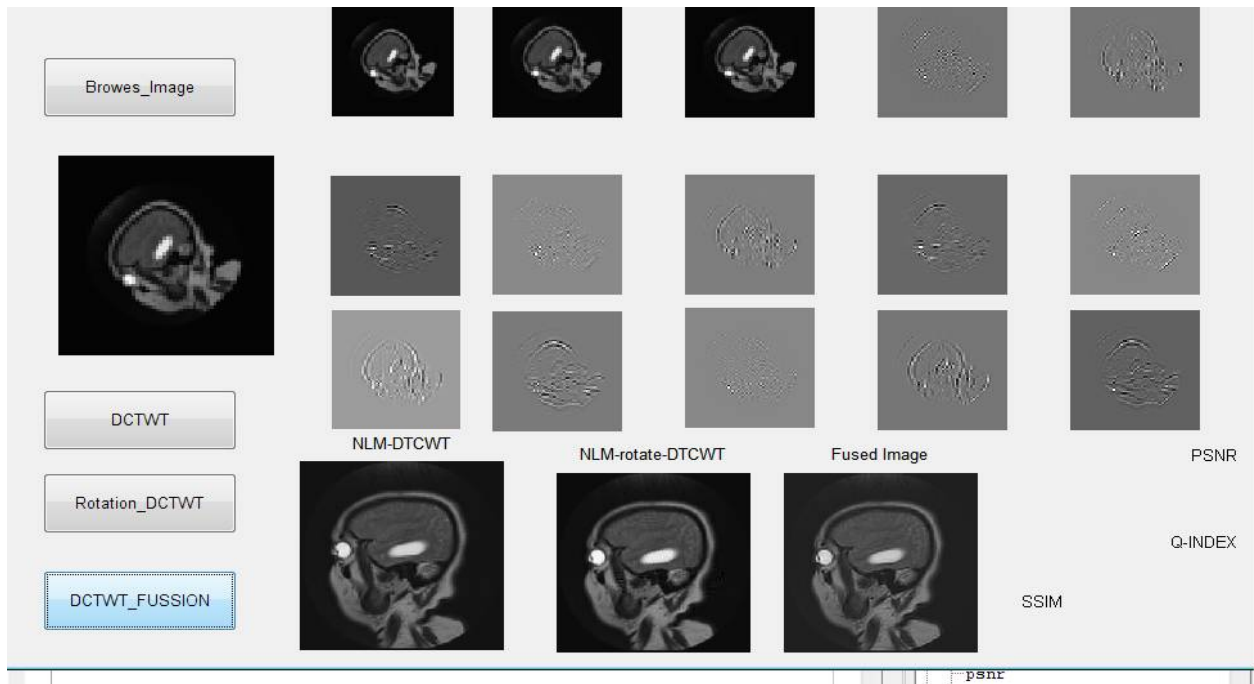


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2)Structural Similarity Index Module value for input image

Input Image	Size	SSIM
MRI	128 X 128	0.9463
MRI	256 X 256	0.9632

V.CONCLUSION

The super resolution for the medical image using DTCWT based image fusion method has been proposed and values of SSIM calculated. The output image is a High resolution image with more image quality.

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