KIET IJCE KIET International Journal of Communications &Electronics
Volume. No. 4, Issue No. 2, July-December 2016, ISSN: 2320 - 8996

MRI Image Enhancement using DT-CWT and Wiener Filter

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Abstract— **MRI Image Enhancement used to enhance the features of images captured by low resolution imaging devices can be implemented using spatial and Fourier Domain Techniques. Spatial domain suffers from drawback of less robustness and it losses HF contents also in case of frequency domain (DWT); the image suffers artifacts due to shift variance property of DWT. To overcome such drawbacks Dual Tree Complex Wavelet Transform (DT-CWT) with Weiner Filter is proposed to enhance Medical Images (MRI). Input images are decomposing using DT-CWT to create HF sub band images. The HF and LF sub band are then Interpolated and filtered using Lanczos interpolation and the wiener filter, finally the filtered HF and LF sub bands are combined using Inverse DT-CWT to produce enhance Images.**

Keywords— **Lanczos; Dual Tree –Complex Wavelet Transform; Peak Signal to Noise Ratio; SSIM.**

I. INTRODUCTION

In medical Image Processing, image enhancement plays a vital role to help Physicians to detect, analyze the defects and provides accurate diagnosis from the low contrast images acquired from imaging devices [2]also enhanced images are further used for image manipulations like segmentation, fusion and recognition etc. Enhancement can be done using spatial techniques and frequency domain techniques which has advantages and disadvantages. Interpolations processes are used for image scaling in image enhancement [3].there are various types of interpolation techniques used (Bilinear, bicubic, nearest neighbor and lanczos). The Lanczos interpolation, a windowed sinc filter is the most superior than nearest neighbor interpolation methods in that the lanczos having ability to detect the edges in image and linear features in an image. This method also offers reduction in aliasing artifacts [1] [3]. The Dual Tree Complex Wavelet Transform (DT-CWT) [1] [4] is the modification to Discrete Wavelet Transform with a property of nearly shift Invariance. It is a multidimensional transform with separate filter banks. The Image super resolution using DT-CWT and NLM has been implemented [1] which shows the better quality of super resolution image than that of DWT and SWT based super resolution techniques. In DT-CWT-NLM filter [1] image enhancement implementation the elapsed time is a major concern.

The proposed method of DT-CWT & Wiener filter shows faster execution and high PSNR and better image quality. Observations are made for MRI images with the help of MSE, PSNR and Structural Similarity Index Module (SSIM).

II. PRELIMINARIES

A. *An Lanczos Interpolator*

Image interpolation is the process of enlarging the image used for processing. Lanczos interpolation is one of the interpolation method used to interpolate images that consist of artifacts. This is simply a windowed sinc function (normalized) given as

$$\sin(x) = \sin(\frac{\pi x}{\pi x})$$

The lancozs interpolation for 1D interpolation is given as

$$I(x) = \sum_{x0-n+1}^{x0+n} L(x0 - n) * I(n)$$

For 2 D interpolation the lanczos interpolation is given as

$$I(x0, y0) = \sum_{j=x0-n+1}^{x0+n+1} I(xi, yi) * L(x0 - i) * L(y0 - j)$$

B. *Dual Tree Complex Wavelet Transform*

The DT-CWT [1] [4] is an improvement to discrete wavelet Transform with the shift invariance property. It is the complex valued extension of discrete wavelet transform. The complex wavelet transform employs two real DWTs, the first DWT gives the real part of transform and second part gives the imaginary part of transform.

DT-CWT calculates the complex transform of a signal using two DWT decompositions. The analysis and synthesis of filter bank used to implement DT-CWT and its inverse.

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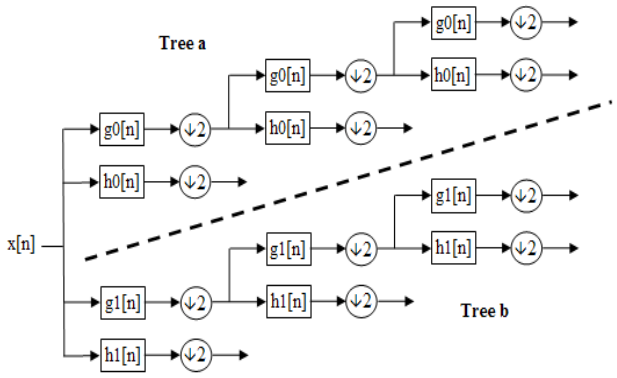

Fig 1. Dual Tree-CWT structure

C. Wiener Filter

The wiener filter [5] is the static linear filter used for image which is degraded by artifacts occurs while processing. The wiener filter mainly used in frequency domain.

For a given degraded image $x(n,m)$, one takes Discrete Fourier Transform to get $X(V,W)$, the original spectra is estimated by taking the product of $X(V,W)$ with filter response$Y(V,W)$.

The wiener filter expression can be expressed in mathematical form as follows

$$G(V,W) = \frac{H^*(V,W)Pn(V,W)}{pn(V,W) + P(V,W)|H(V,W)|^2}$$

III. IMPLEMENTATION

In Proposed Method (DT-CWT-WIENER), The Input Image is first decomposes into main two sub bands (here C_i and W_i^j) using Dual Tree-CWT. Where here C_i values are the Image coefficient sub bands & W_i^j are the wavelet coefficient sub bands. W_i^j Values then allowed interpolating with a factor β using Lanczos interpolation and combines with β/2 interpolated Input LR Image. Since C_i contains Low pass filtered image of the LR input image, therefore High Frequency information of input image is missing, thus to collect HF component of image we use complete input image instead of C_i . Though Dual Tree –Complex Wavelet Transform is nearly Shift Invariant [4], however it may produce some artifacts after the interpolation is done using W_i^j .therefore to collect these artifacts wiener filter is used. All interpolated W_i^j values are passed through then wiener filter. By applying the inverse Dual Tree-Complex Wavelet Transform to these filtered sub bands along with the input image to reconstruct the enhanced Image.

D. Graphical Representation of Proposed Method

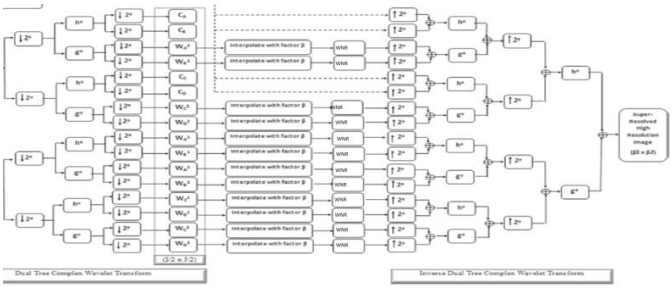

Fig 2. Blok diagram of Proposed Method

E. Observation

For the proposed Method using Lanczos interpolation, the MRI image is taken as a test image and this image is applied to three algorithms which consist of Bicubic interpolation, Nearest neighbour and Lanczos interpolation with Dual Tree-CWT and Wiener Filter. The observation for each algorithm is as follows

TABLE 1

DT-CWT-WIENER METHOD

Interpolation used	Input Image size	Output Image Size	MSE	PSNR	SSIM
Bicubic Interpolation	288	576	3.71976	42.8567	0.94211
Nearest Neighbor	288	576	3.36827	42.4257	0.96424
Lancoz Interpolation	288	576	3.74435	42.397	0.96426

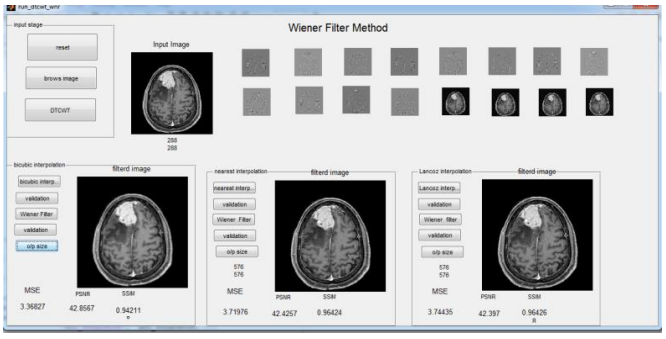

Fig 3. MATLAB GUI for Observation

IV. CONCLUSIONS

The Image Enhancement for MRI Image based on Dual Tree-Complex Wavelet Transform with the Wiener Filter has been implemented. This technique allows decomposition of the input image using Dual Tree-Complex Wavelet Transform, wavelet coefficient and input image were interpolated using Lanczos Interpolator.

Dual Tree-CWT has the property of shift invariance and generates very few artifacts as compared to discrete wavelet Transform. Wiener filter is used to remove the artifacts generated by Dual Tree-CWT. The performance of implemented technique can be given in term of Mean square error, peak signal noise ratio and Q factor.

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