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Image Enhancement using DCTWT and Interpolation Techniques

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ABSTRACT

As image enhancement is the main issue for biomedical images, this paper aims to present the methods using wavelets to enhance it. Digital image processing plays a vital role in today's new digital imaging devices. To perform the operation on the low-quality input images, frequency domain manipulations are widely used. Image enhancement is one of the types of processing in digital image processing domain. To perform this operation sophisticated wavelet transformation is used which has better enhancement as compared to their spatial domain counterpart. In the proposed paper, a novel technique for the biomedical image, general images up to certain MB enhancement using dual-tree complex wavelet transform is used. Dual-tree complex wavelet is a parallel combination of two discrete wavelet transform which has the property of shift invariance which results in lesser artifacts generated in output enhanced image. Interpolation is using for high precision in this paper B-spline interpolation give better results. To perform this operation and finding out the best possible transform among the available wavelet family. Proposed implementation has three transforms namely symlet, D'mayer, Daubechies, and haar transform are used. The input image is first decomposed using a wavelet transform to generate frequency bands, values of PSNR, Q-index and SSIM are calculated for study enhancement results.

Keywords— *DCTWT, PSNR, MSE, SSIM, Image enhancement*

1. INTRODUCTION

The process of enhancing the quality of the digital image from a low-quality input image[4] is referred to as image enhancement[4][5][10]. resolution enhancement and contrast enhancement are some types of image enhancement. The quality of the image generated from the source can be degraded due to various factors such as the use of low-resolution image and the problem of aliasing due to improper selection of sampling rate.

The problem of aliasing can be overcome by use of image interpolation[5][9] but the main drawback of using image interpolation is the loss of HF components that are edges of images which are due to smoothing effect caused by image interpolation. In order to reduce the drawback of smoothing instead of using interpolation, the frequency decomposition tool is used nowadays. currently, various frequency domain techniques are used such as Fourier transform, Stationary wavelet transform(SWT)[2], Discrete wavelet transform (DWT)[2] and Dual Tree complex wavelet transform (DTCWT)[3]. Among these available frequency transformation tools, Dual tree complex wavelet transform is popular because of the property of shift invariance. This transform is used to decompose the input image to be enhanced into different frequency components called frequency sub-bands.

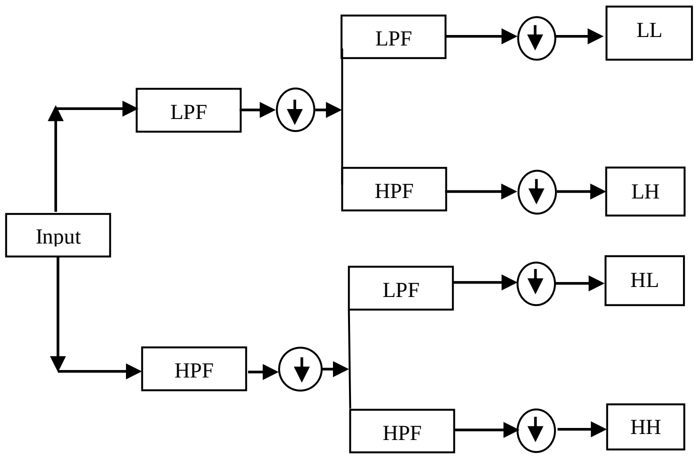
2. DUAL TREE COMPLEX WAVELET TRANSFORM

The dual-tree complex wavelet transform is a filter bank structure formed by using a parallel combination of two DWTs. This combination can be used into multiple levels like 1 level, 2 level, 3 level and so on where the parallel combination is arranged in tree form.

Basic DWT can be expressed mathematically as:

$$\varphi s,\tau(t) = \frac{1}{2^j}\,\varphi\left(\frac{t - k * 2^\wedge j}{2^\wedge j}\right)$$

where s and τ are scaling and translation parameters of wavelet transform. φ is the fundamental mother wavelet.



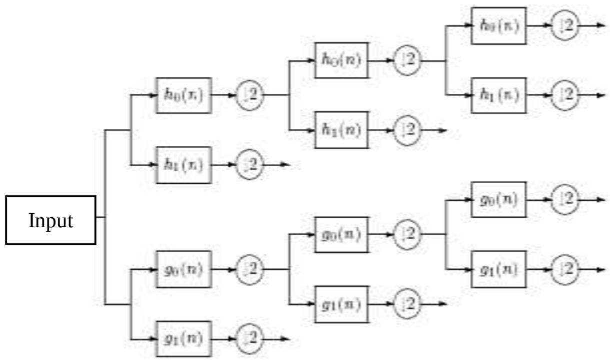


Fig. 1: Dual-Tree Complex wavelet Transform

2.1 Wavelet Family

Wavelet is a mathematical function that divides the data into different frequency components where each component are a scaled version of some predefined sample signal called basis functions. these basis functions are having limited duration called wavelet. these basis functions are scaled with respect to frequency.

various sample signal in wavelet collectively called wavelet family. Haar, Daubechies, symlet are the sample functions.

2.1.1 Haar Transform

It is the basic sample function used in wavelet domain analysis. it is also called a 1db signal. this signal is symmetrical.

mathematically the function is given as

$$\varphi(x) = \begin{cases} 1, & 0 < x < 1/2 \\ -1, & \frac{1}{2} < x < 1 \end{cases}$$

2.1.2 Daubechies Transform

In Daubechies, N is the order. some of the db is used as 2N instead of N. the support vector length of Ψ and ψ is 2N-1. the no. of vanishing moments of Ψ is N. most dbN are not symmetric. the regularity increases with increase in order.

2.1.3 Symlet Transform

In symlet, N is the order. some of these transforms are used as 2N instead of N. symlet are only near symmetric.

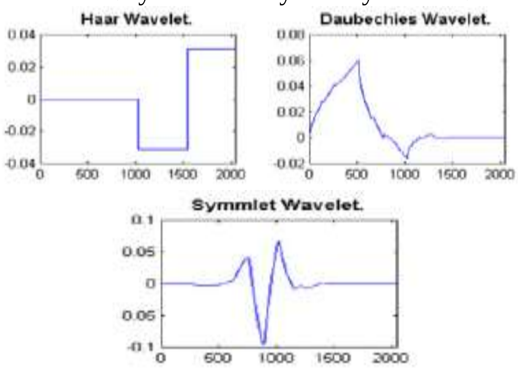


Fig. 2: Haar, Daubechies and symlet transform

3. IMPLEMENTATION

To implement the image enhancement for biomedical[1][4] input images. a 3 level dual-tree complex wavelet transform with different mother wavelet transform is used. There are two phases for implementations.

i. **Normal DTCWT implementation**: In this phase, an input image is allowed to decompose into frequency sub-bands with the orientations of subbands are the same as the input.

ii. **Rotational DTCWT implementation**: In this phase, the generated subbands will have additional inclinations as compared to input.

The complete procedure for the implementation is as follows:

i. Ccollecting the MRI input image dataset with size

ii. Application of DTCWT and rotational DTCWT to decompose the input MRI images.

iii. Use of Haar transform, Daubechies and symlet transform at each use cases.

iv. Generation of image parameters like PSNR and MSE for each transformation.

4. OBSERVATIONS

To perform the analysis using the proposed implementation, suitable MRI images are taken. dual-tree complex wavelet transform performs decomposition results in frequency bands. After processing these subbands are once again converted into a spatial image by using Inverse dual-tree complex wavelet transform. The values of PSNR and MSE are generated for each input size images. The wavelet transform used here are more reliable and provide exceptional information for dissimilar resolution.

It is found that the values of PSNR and MSE generated by Haar transform based DTCWT are better than implementation done using Daubechies and symlet based DT-CWT.

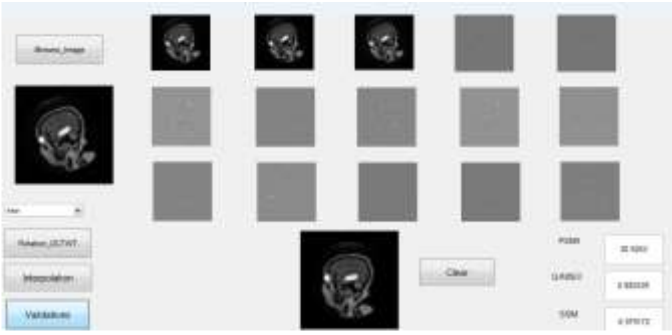


Fig. 3: validating result images

Table 1: Observation table

	Haar			daubechies			Symlet		
In_Image	PSNR	SSIM	Q index	PSNR	SSIM	Q index	PSNR	SSIM	Q index
03_2	30.9263	0.979172	0.882528	30.8846	0.979172	0.882548	30.949	0.979156	0.832588
04_2	29.9295	0.961899	0.883101	29.9277	0.96196	0.883101	29.9587	0.96194	0.883081
05_2	29.5541	0.949799	0.883516	29.5551	0.949829	0.883674	29.6407	0.949829	0.883556
06_2	27.8233	0.93634	0.884286	27.8116	0.936371	0.884286	27.964	0.936386	0.884346

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