Medical Image Denoising and Enhancement using DTCWT and Wiener filter

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ABSTRACT

Image denoising is the process to remove the noise from the image which contains noise. Wavelet transform technique is a unique mathematical manipulation framework used for medical image denoising and enhancement implementation. The wavelet techniques are effective to remove the noise due to their ability to capture the energy of a signal in a few energy transform values. A dual-tree complex wavelet transform is used to present the image enhancement process. The proposed technique has the cascaded structure of DTCWT used for generation of different frequency bands for analysis. In this paper, a denoising approach based on dual-tree complex wavelet and Wiener filter technique is used. The result has a better balance between smoothness and accuracy than the DWT and is less redundant than SWT. We used the SIM (Structural Similarity Index Measure) along with PSNR (Peak Signal to Noise Ratio) to assess the quality of denoised images.

Keywords: Image Enhancement, DTCWT, PSNR, MSE, Interpolation, SSIM, Filter

1. INTRODUCTION

Nowadays the quality of digital medical images becomes an important issue. To achieve the best diagnosis it is important that medical images should be sharp, clear, and noise free. Removal of noise is effective in medical imaging applications in order to enhance and recover very minute details which may be hidden in the data.

During transmission and reception, images are usually affected by noise which cannot be easily eliminated in image processing applications. This appears owing to the real signals getting corrupted by unwanted signals. These noises occur as random black and white snow-like patterns on screens. The purpose of the de-noising algorithm is to remove such noise. Image de-noising and image enhancement appear to be the same. But both are entirely different processes. Enhancement of an image is an objective process, whereas de-noising of an image is a subjective process.

In image de-noising by using prior knowledge of the degradation process attempts are made to recover the degraded image. Image enhancement does manipulation of the image characteristics to make it more appealing to the human eye. Image de-noising techniques are broadly classified into spatial domain and transform domain techniques. The spatial domain techniques use simple spatial filters such as Lee, Kalman, foster, median, mean filters etc. In this technique, data operation is carried out on the original image by processing the grayscale value.

In this paper, we have proposed a modified technique which is based on dual-tree complex wavelet transform and interpolation. The main focus is to enhance the resolution of a low-resolution medical image. After obtaining the high-resolution output image, classification results and various quality assessment parameters like PSNR, SSIM, and MSE are used to test this resolution enhancement technique.

1.1 PSNR, MSE, SSIM
1.1.1 PSNR: PSNR stands for peak signal to noise ratio, is a ratio between the maximum power of a signal and the power of corrupting noise that affect the fidelity in the image signal. It is generally measured in decibel scale as the signals are having wide dynamic range. Higher the value of PSNR indicates that the image reconstruction is of higher quality. Mathematically the PSNR in terms of MSE can be given as:

$$PSNR = 10 \log_{10} \left( \frac{MAX^2}{MSE} \right)$$

Where, the MAX is the maximum possible pixel value present in the image.

1.1.2 SSIM: Structural Similarity Index Module (SSIM) is again a perceptual metric that quantifies the image quality degradation caused by processing images. It is a full reference metric that requires two images from the same capture.

1.1.3 MSE: Mean squared error is used to determine the quality of the image. It is another parameter to check the quality of the reconstructed image.

1.2 Wavelet transform

A wavelet transform is a tool that cuts up the data, function or operation into different frequency components and then studies each component with a resolution matched to its scale.
The generalized form of Wavelet Transform is given by:

\[ f(a,b) = \int_{-\infty}^{\infty} f(x) \varphi^*(a,b)(x)dx \]

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 signals in wavelet collectively called wavelet family. Many of the wavelet families are proven to be very useful. Wavelet families are Daubechies, Haar, symlet, biorthogonal, morlet, Mexican hat.

A bi-cubic interpolation is an extension of cubic interpolation for interpolating data points on 2D regular pixel grids. The bi-cubic interpolation results much smoother image results than bilinear and nearest neighbor interpolation. In the bi-cubic, the average value of the interpolated pixel is calculated using surrounding 16 pixels in a grid image.

### 1.5 Wiener Filter

The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously. The Wiener filtering is optimal in terms of the mean square error. In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing. The Wiener filtering is a linear estimation of the original image. The orthogonality principle implies that the Wiener filter in Fourier domain can be expressed as follows:

\[ W(f_1,f_2) = \frac{H^*(f_1, f_2)S_{xx}(f_1, f_2)}{|H(f_1, f_2)|^2S_{xx}(f_1, f_2) + S_{yy}(f_1, f_2)} \]

### 2. PROPOSED SYSTEM

Any de-noising algorithm that uses the wavelet transform consist of three steps: first calculate the wavelet transform of the noisy signal image, modify the noisy wavelet coefficient according to some value and finally compute the inverse transform using the modified coefficients. We decompose the Low Resolution (LR) input images into different frequency sub-bands using six decomposition level. These sub bands are high frequency and low-frequency sub bands. These sub bands are assigning the values that are the wavelet coefficients of the respective frequency bands.

In case of multichannel case, each channel is separately treated. These sub bands are applied to a de-noising filter called wiener filter used to remove noise present in the input database. The wiener filter output is then applied to inverse Dual tree complex wavelet transform to recover the distortionless image. After the de-noising process, the input image is once again applied to the dual-tree complex wavelet transform for decomposition into frequency sub-bands for enhancement purpose. These sub bands are then applied to image interpolation. These sub bands after interpolation applied to the inverse dual-tree complex wavelet transform to get final enhanced output image.
3. RESULT
To implement the image enhancement for medical input images a cascaded form of two dual-tree complex wavelet transform structure along with image interpolation and Wiener filter is used.

Some of the input images taken are as follows:

![Fig. 5: Input Image 1](image1.png) ![Fig. 6: Input Image 2](image2.png)

The output of image 1 is shown below:

![Fig. 7: Output Image](output.png)

4. OBSERVATION TABLE

<table>
<thead>
<tr>
<th>Stage I</th>
<th>Input Image</th>
<th>MSE</th>
<th>PSNR</th>
<th>SSIM</th>
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</table>

5. CONCLUSION
It is concluded that the results obtained from the implemented DTCWT structure have better image quality formation than that of other methods.

6. ACKNOWLEDGMENT
Author is thankful to Prof. S. P. Bhosale department of electronics and telecommunication engineering, AISSMS COE Pune for his valuable guidance.

7. REFERENCES
[1] Du-Yin Tsai, Yongbum, "A Method of Medical image enhancement using wavelet coefficient mapping function" department of radiological technology, 2014
[8] Pejman Rasti, Hasan Demirel, "Image Resolution enhancement by using interpolation followed by iterative back projection".