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Comparison of 2-D Complex Dual-Tree DWT and Adaptive Filtering Techniques for MRI denoising

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Abstract— *In quest to find the best denoising technique for Magnetic Resonance Images (MRI) and hence providing the medical practitioners the best images for diagnosis, we use many modern denoising techniques. In one of the previous work, out of various wavelet techniques, complex 2-D dual tree DWT was proved to be one of the best. In this work, we compared this technique with two filtering techniques: Median and Weiner filters. Gaussian and random types of noises in the images have been considered and results have been analyzed. RMS error values thus obtained have been compared. We have found that, out of these three techniques, complex dual tree DWT again proves to be best.*

1. INTRODUCTION

Wavelet thresholding (or "shrinkage") is a well nown image denoising technique. When we decompose data using the wavelet transform, we use filters that act as averaging filters, and others that produce details. Some of the resulting wavelet coefficients correspond to details in the data set (high frequency sub-bands). If the details are small, they might be omitted without substantially affecting the main features of the data set. The idea of thresholding is to set all high frequency sub-band coefficients that are less than a particular threshold to zero. These coefficients are used in an inverse wavelet transformation to reconstruct the data set [1]. Generally we can use three different methods to remove the noise from an image. These methods are using separable 2-D DWT, real 2-D dual-tree DWT, and complex 2-D dual-tree DWT. Infact, in medical field, various researchers use complex 2-D dual tree DWT alongwith other filters generally [2]. Out of these three techniques, Complex 2-D dual tree DWT proves to be best.

Complex 2-D dual-tree DWT gives rise to wavelets in six distinct directions, however, in this case there are two wavelets in each direction as will be illustrated below. In each direction, one of the two wavelets can be interpreted as the real part of a complex-valued 2D wavelet, while the other wavelet can be interpreted as the imaginary part of a complex-valued 2D wavelet. Because the complex version has twice as many wavelets as the real version of the transform, the complex version is 4-times expansive. The complex 2-D dual-tree is implemented as four critically-sampled separable 2-D DWTs operating in parallel. However, different filter sets are used along the rows and columns. As in the real case, the sum and difference of subband images is performed to obtain the oriented wavelets.

However, we have other filters also (like Weiner and Median filters) which give impressive results in image denoising. Hence one needs to compare the 2-D complex dual tree DWT technique with these filtering techniques to find out which is the best.

Median Filtering: With Median Filtering, the value of an output pixel is determined by the median of the neighborhood of pixels,rather than the mean.The median is mcuh less sensitive than the mean to extreme values.Therefore it is better able to remove this oulier withot reducing the sharpness of the image.

Adaptive Filtering: The weiner function applies a Weiner filter which is a type of linear filter to an image adaptively,tailoring otself to local image variance.This approach often produce better result than linera filtering preserving edges and other hign frequency parts of image.Wiener2 works best when the noise is constant –power(“white”)additive noise,such as Gaussian noise.

2. METHODOLOGY

All the computational work has been performed on MATLAB (2008) software. We have used an MRI image of the brain of a female patient and have introduced two different noises for better comparison: Random noise (with variance 20) and Gaussian noise (with variance 0.025). Then RMS errors (with respect to original image) have been calculated for threshold value 20 with complex 2-D dual tree discrete wavelet transform and with Weiner and Median filtering techniques. These errors have been tabulated (Table – 1) for better understanding. The various steps used in this soft thresholding are:

A. Read an input image,

B. Add noise to the input image and compute RMS error, C. Use filter bank for first stage and remaining stages,

D. Set J (number of stages and T (threshold value),

E. Compute forward DTCWT,

F. Compute inverse DTCWT,

G. Extract output image and compute RMS error.

3. RESULTS AND CONCLUSIONS

RMS errors of noisy, denoised by complex dual tree DWT, Weiner and Median filtering techniques have been calculated with respect to the original image and have been shown in table 1. RMS error for random noisy image was 20.191. It is clear that complex 2_D dual tree DWT is best among these three techniques to denoise a random noise. Noisy picture and denoised using complex 2-D DTDWT have been shown in figures 2a, and 2b for comparison.

Table 1: Values of RMS error (with respect to original image)

Type of noise	Weiner filter	Median filter	Complex DTDWT
Random noise	7.6910	8.9858	7.1599
Gaussian noise	59.4410	59.4229	59.4540

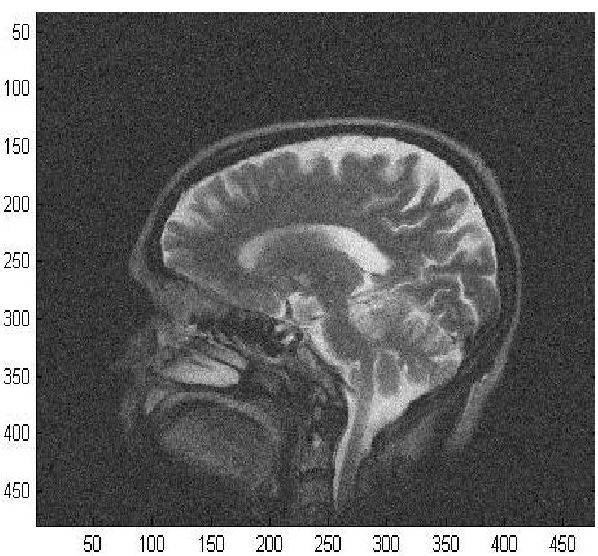

Figure 2a: Output of noisy image

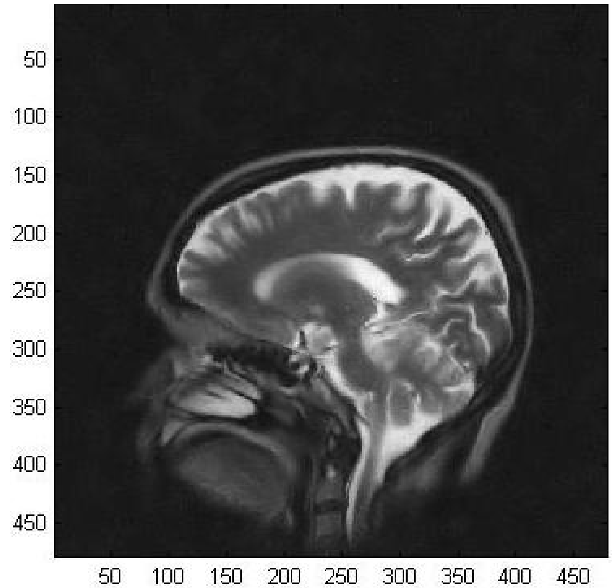

Figure 2b: Output of denoised image by 2D complex dual tree DWT

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