# A COMPARATIVE STUDY OF DIFFERENT WAVELET ECHNIC: DENOISING THE SPECKLE NOISE FOR ULTRASOUND IMAGES USING LABVIEW

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***Abstract -*** Biomedical images are generally corrupted by speckle noise and Gaussian noise. Speckle noise is multiplicative type whereas other noises like Gaussian noise are additive type. It is difficult to remove multiplicative noise from images. Latest domain in the field of Image denoising and compression is using wavelet analysis. Multiresolutional image analysis using wavelets is the latest modification in the field of image enhancement and denoising. Speckle Noise is the high frequency content in the ultrasound images and can be easily removed using wavelet based thresholding technique. This paper presents study of various techniques for removal of speckle noise from images, used in biomedical applications, such as Spatial and frequency domain filter and a modified algorithm for speckle noise reduction using wavelet based multiresolutional analysis and thresholding function has been proposed incorporating different wavelets such as Haar, Coiflets, Daubechies and Symlets.

***Keywords*** *— Speckle Noise, noise filtering techniques, Multiresolutional, Wavelet thresholding, DWT transform, LabVIEW tools.*

## 1. Introduction

Ultrasound method is one of the best imaging methods for soft tissue of body, because it is portable, no ionic radiation is used and it is relatively cheap, but the main disadvantage of this method is that images taken by this method has low quality of images that is in turn due to the presence of multiplicative noise. Speckle noise is multiplicative type whereas other noises like Gaussian noise are additive type. It is difficult to remove multiplicative noise from images.

In medical imaging, such as ultrasound images, image is generated with the help of ultrasonogram, but the basic problem in ultrasound images is speckle noise gets introduced in it. Speckle noise becomes a dominating factor in degrading the image visual quality and perception in many other images. Noise is introduced at all stages of image acquisition. There could be noises due to loss of proper contact or air gap between the transducer probe and body or noise could be introduced during the beam forming process and also during the signal processing stage. Even during scan conversion, there could be loss of information due to interpolation.

## 2. Related Study

Up to now, the major despeckling techniques can be loosely grouped in four categories: 1) spatial; 2) wavelet-based; 3) nonlocal filtering; and 4) variational;

They used Wiener filter, anisotropic diffusion filter, k distribution based adaptive filter and wavelet filter to de-speckle in medical ultrasound images. The Wiener filter can improve the image qualities well and simulated power spectrum of speckle can be applied on many situations.

- Multiresolution - image details of different sizes are analyzed at the appropriate resolution scales
- Sparsity - the majority of the wavelet coefficients are small in magnitude.
- Edge detection - large wavelet coefficients coincide with image edges.
- Edge clustering - the edge coefficients within each sub band tend to form spatially connected clusters.

## 3. Proposed Approach

Latest domain in the field of Image denoising and compression is using wavelet analysis. Multiresolutional image analysis using wavelets is the latest modification in the field of image enhancement and denoising. Wavelet analysis represents the next logical step: a windowing technique with variable-sized regions. Wavelet analysis allows the use of long time intervals where we want more precise low-frequency information, and shorter regions where we want high-frequency information. Speckle Noise is the high frequency content in the ultrasound images and can be easily removed using wavelet based thresholding technique[4].

## 4. Problem Formulation

### A. Medical Ultrasound Speckle Pattern

Creation of speckle pattern based the number of scatters per resolution or scatter number density. For the spatially distribution and the characteristics of the imaging system can be divided into three classes: In the first category, fully formed speckle pattern occurs when many random distributed scattering exists within the resolution cell of the imaging system. Blood cells are the example of this class. The second category of tissue scatters is no randomly distributed with long-range order [4]. The third category occurs when a spatially invariant coherent structure is present within the random scatter region like organ surfaces and blood vessels [4].

### B. Speckle Noise representation

Here u(x, y) represents the objects (means the original image) and v(x, y) is the observed image. Here h (x, y; x’, y’) represents the impulse response of the image acquiring process. The term ŋ(x, y) represents the additive noise which has an image dependent random components f [g(w)] ŋ1 and an image independent random component ŋ2. A different type of noise in the coherent imaging of objects is called speckle noise. Speckle noise can be modeled as

$$V(x, y) = u(x, y)s(x, y) + n(x, y) \ldots\ldots \quad (4)$$

Where the speckle noise intensity is given by s(x, y) and ŋ(x, y) is a white Gaussian noise [1]-[3]. The main objective of image-de-noising techniques is to remove such noises while retaining as much as possible the important signal features. One of its main shortcomings is the poor quality of images, which are affected by speckle noise.

In ultrasound imaging, however, the unified definition of such a model still remains arguable. Yet, there exist a number of possible formulae whose probability was verified via their practical use. A possible generalized model of the speckle imaging is

$$g(n, m) = f(n, m)u(n, m) + \xi (n, m) \ldots (5)$$

Where g, f, u and ξ stand for the observed image, original image, multiplicative component and additive component of the speckle noise basically. Here (*n* , *m* ) denotes the axial and lateral indices of the image samples or, alternatively, the angular and range indices for B-scan images. When applied to ultrasound images, only the multiplicative component of the noise is to be considered; and thus, the model can be considerably simplified by disregarding the additive term, so that the simplified version of (5) becomes,

$$g(n, m) = f(n, m)u(n, m) \ldots\ldots\ldots\ldots\ldots (6)$$

Homomorphic de-speckling methods take advantage of the logarithmic transformation, which, when applied its converts the multiplicative noise to an additive one. Denoting the logarithms of g, f *and u* by *gl*, *fl*, and *ul*, respectively, the measurement model becomes

$$g\,1(n, m) = f1\,(n, m)u1\,(n, m)\ (7)$$

At this stage, the problem of de- speckling is reduced to the problem of rejecting an additive noise, and a variety of noise-suppression techniques could be evoked in order to perform this task [1]-[12].

**C. Discrete Wavelet Transform**

Unlike the discrete Fourier transform (DFT), which is a discrete version of the Fourier transform, the discrete wavelet transform (DWT) is not really a discrete version of the continuous wavelet transform (CWT).

If no processing takes place between the two filter banks, the sum of outputs of $H0(z)$ and $H1(z)$ is identical to the original signal $X(z)$, except for the time delay. This system is a two-channel PR filter bank, where $G0(z)$ and $G1(z)$ form an analysis filter bank, and $H0(z)$ and $H1(z)$ form a synthesis filter bank. Traditionally, $G0(z)$ and $H0(z)$ are low pass filters, and $G1(z)$ and $H1(z)$ are high pass filters..

**D. Coiflets**

Built by I. Daubechies at the request of R. Coifman. The wavelet function has 2N moments equal to 0 and the scaling function has 2N-1 moments equal to 0. The two functions have a support of length 6N-1. Coiflet scaling functions also exhibit vanishing moments. In coifN, N is the number of vanishing moments for both the wavelet and scaling functions. These filters are also referred to in the literature by the number of filter taps, which is 2N.

**E. Symlets**

The properties of the two wavelet families are similar. Here are the wavelet functions psi. The symN wavelets are also known as Daubechies' least-asymmetric wavelets. The symlets are more symmetric than the extremal phase wavelets. In symN, N is the number of vanishing moments. These filters are also referred to in the literature by the number of filter taps, which is 2N.

### F. Haar Wavelets

Haar wavelet is the first and simplest.

Haar wavelet is discontinuous, and resembles a step function. It represents the same wavelet as Daubechies db1

### G. Daubechies Wavelet

Ingrid Daubechies, one of the brightest stars in the world of wavelet research, invented what are called compactly supported orthonormal wavelets -- thus making discrete wavelet analysis practicable. The names of the Daubechies family wavelets are written dbN, where N is the order, and db the "surname" of the wavelet. The db1 wavelet, as mentioned above, is the same as Haar wavelet. Here is the wavelet functions psi of the next nine members of the family:

### H. Wavelet Domin Noise Filtering

Recently there has been significant investigations in medical imaging area using the wavelet transform as a tool for improving medical images from noisy data. Wavelet denoising attempts to remove the noise present in the signal while preserving the signal characteristics, regardless of its frequency content. As the discrete wavelet transform (DWT) corresponds to basis decomposition, it provides a non-redundant and unique representation of the signal. Several properties of the wavelet transform, which make this representation attractive for denoising, are

- Multiresolution - image details of different sizes are analyzed at the appropriate resolution scales.
- Sparsity - the majority of the wavelet coefficients are small in magnitude.
- Edge detection - large wavelet coefficients coincide with image edges.
- Edge clustering - the edge coefficients within each sub band tend to form spatially connected clusters.

### I. Multiresolution Analysis

Wavelet analysis represents the next logical step: a windowing technique with variable-sized regions. Wavelet analysis allows the use of long time intervals where we want more precise low-frequency information, and shorter regions where we want high-frequency information.

## 5. Wavelet Decomposistion

Using the LabVIEW Wavelet Analysis Tools, you can extend the discrete wavelet transform (DWT) to 2D signal processing. The following figure shows the PR filter bank implementation of the 2D DWT, which applies the filter banks to both rows and columns of an image.

The source image decomposes into the following four sub-images:

a. low_low—Shows an approximation of the source signal with coarse resolution.
b. low_high—Shows the details at the discontinuities along the column direction.
c. high_low—Shows the details at the discontinuities along the row direction.
d. high_high—Shows the details at the discontinuities along the diagonal direction.

You can apply the decomposition iteratively to the low-low image to create a multi-level 2D DWT, which produces an approximation of the source signal with coarse resolution. You can determine the appropriate number of decomposition levels for a signal-processing application by evaluating the quality of the decomposition at different levels.

## 6. Result Analysis

The quality of an image is examined by objective evaluation as well as subjective evaluation. In subjective evaluation, the image has to be observed by a human expert. The human visual system is so complicated that it is not yet modeled properly. Therefore, in addition to objective evaluation, the image must be observed by a human expert to judge its quality.

**Performance Of Noise Removal using wavelet Multiresolution**

| Wavelet type | PSNR(db) | Standard Deviation | Correlation factor of reconstructed image | RMS |
|---|---|---|---|---|
| **Haar** | **42.890** | **42.773** | **0.969** | **13.443** |
| **Db2** | **40.832** | **42.527** | **0.945** | **13.440** |
| **Db3** | **38.690** | **41.931** | **0.991** | **13.467** |
| **Sym2** | **40.832** | **42.527** | **0.946** | **13.440** |
| **Sym3** | **38.690** | **41.931** | **0.991** | **13.467** |
| **Coif1** | **39.121** | **42.944** | **0.982** | **13.494** |

**Fig.1 PSNR value table of different wavelet types.**

If the image PSNR value high means quality image will be high. so, Haar wavelet will produce the best result for denosing the speckle noise compare to other wavelets.

## 7. Conclusion And Future Work

In this paper, a comparative analysis is done for the different wavelet techniques for denoising and this technique follows a quantization approach that divides the input image in 4 filter coefficients and then performs further quantization on the lower order filter or higher order filter. LABVIEW software is used to implement the design. Discrete wavelet transform will be applied to construct the detail and approximation coeffients and after multilevel decomposition and filtering, reconstruction image will be created using reconstruction coeffients. With different type of wavelet like Haar, Coiflets and Symlets are analyzed for denoising the speckle noise in ultrasound images. In future, work can be done to implement this algorithm of multiresolutional analysis presented in this thesis on other types of medical imaging like CT Scan, MRI and EEG images under various different kinds of noise like speckle noise, gaussian noise, etc.

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