Speckle Noise Reduction based on Discrete Wavelet Transform

Inderjeet Singh
Student, M.Tech (CE)
UCOE, Department of CE.
Punjabi University, Patiala

Er.Lal Chand
Assistant Professor
UCOE, Department of CE
Punjabi University, Patiala

Abstract

Medical images or ultra sound images are typically used in the medical fields for lots of purposes. Many problems occurred in the medical images. Main problem related to this imaging technique is introduction of speckle noise which blurs or degrades the superiority of the image. Speckle noise makes the image indistinct which is tough to see clearly. There have been several techniques to de-noise the speckle noise from the images. The main goal of this thesis is that this proposed DWT+Wiener filter technique is better denoising technique than the other traditional techniques such as: wiener filter, median filter, homomorphic wiener filter and homomorphic median filter to remove the speckle noise from the image. It gives the better PSNR (peak signal to noise ratio) value than the other filters. This shows the better denoisy image or clear image than the other traditional filter techniques.

Keywords: Leena images, speckle noise, dwt, wiener filter, wavelet transform.

I. Introduction

Sound which is unpleasant, loud or undesired that is called noise. Noise is very difficult problem in the field of image processing. This problem has existed for a long time and yet there is no good solution for it. The main occurrences of noise in a digital image may arise during image acquisition and image transmission. Noise has two types multiplicative and additive noise. Generally, additive noise can be easily removed from an image but on the other hand multiplicative noise is difficult to remove from images. Depending upon the nature of noise, there are various several approaches for removal of noise from an image. A different type of noise in the coherent imaging of objects is called speckle noise [2]. For resolution objects it is often multiplicative and occurs whenever the surface roughness of the object image is of the order of wavelength of incident radiations for example. When a photograph is digitized using the optical scanners, speckle noise can occur because the roughness of the paper surface is of order of wavelength of the light used for scanning. Speckle noise can be modeled as

$$v(x,y) = u(x,y)s(x,y) + \eta(x,y) \ldots\ldots (1)$$

Where the speckle noise intensity is given by s(x, y), u(x, y) is speckle noise and η (x, y) is a white Gaussian noise [1].

The noise may be created or uncorrelated; it may be signal dependent or independent and so on. We describe two important classes of noise here:

Additive noise: Sometimes the noise generated from the sensors is thermal white Gaussian; it is additive in nature represented by following equation

$$g(x,y) = f(x,y) + \eta(x,y) \ldots\ldots (2)$$

Where g(x, y) is result of the original image function f(x, y) is corrupted by additive Gaussian noise is represented by η (x, y) in above equation.

Multiplicative noise: The grain less noise from the photographic plate is essentially multiplicative in nature. The speckle noise from the imaging system as in coherent SAR, ultrasound imaging etc. are also multiplicative in nature which may be modeled as:

$$g(x,y) = f(x,y) \times \eta(x,y) \ldots \qquad (3)$$

Where η (x, y) is the multiplicative noise.

The main objective of image-de-noising techniques is to remove such noises while retaining as much as possible the important signal features. Ultrasonic imaging is a widely used medical-imaging procedure. One of its main shortcomings is the poor quality of images, which are affected by speckle noise. The existence of speckle is unattractive since it disgraces image quality and affects the tasks of individual interpretation and diagnosis. Accordingly, speckle filtering is a central pre-processing step for feature extraction, analysis and recognition from medical-imagery [1][3][4].

II. Image Denoising Techniques:

There are many speckle reduction filters available, some give better visual interpretations while others have good noise reduction or smoothing capabilities. Some of the best known speckle noise reduction filters are median wiener filter, lee filter, Kuan filter and frost filters.

Some these filters are based on spatial filtering in a square moving window known as kerne .It works only on the centre pixel and its surrounding pixels. The size of the filter window can range from 3 by 3 to 33 by 33, but the size of the window must be odd. If the size of the window will too large then the important information will be lost due to over smoothing and if the size of the window is too small then it will not give the good results. Mostly 3 by 3 or 7 by 7 is used as it gives good results [9].

A. Median filter

The median filter works on the centre pixel means. It works by moving through the image pixel by pixel, replacing each value within the median value of neighboring pixel. The pattern of neighbors is called window, which slides pixel by pixel, over the entire image. The median is calculated by first sorting all the pixels values from the window into the numerical order, and then replacing the pixel being considered with the middle pixel value. It is non linear filtering technique. It is specially used to remove the salt and pepper noise. It is effective in the strong spike components and the characteristics to be preserved are edges. The main disadvantages of the median filter is that it takes lots of time and the extra computation time needed to sort the intensity value of each set [5].

B. Wiener filter

Wiener filter also known as least mean square filter. Wiener filter proposed in the year of 1942 is adaptively applied on the image according to the variance. It minimizes the overall mean square error in the process of inverse filtering and noise smoothing. It is the linear estimation of the original image [10]. If the variance is small, wiener performs smoothly; if the variance is large then the wiener performs less smoothly. This approach gives the better result than the linear filters. Wiener filter gives the following expressions:

$f\ u, = H\ u, *H\ u,v\ 2+\ Sn\ u,v\ Sf\ u,v\ G(u,v)$ (1)

H(u,v)2 is the degradation function and H(u,v)∗ is the conjugate complex. G (u, v) is the degraded image. Functions S1 (u, v) and Sn (u, v) are power spectra of original image and the noise [6].

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III. Proposed Wavelet based image denoising:

There are several denoising techniques to reduce the speckle noise with using the wavelets. Wavelet noising filtering: we will use the wavelet noise thresholding which is Discrete Wavelet Transform (DWT). In the case of DWT first the image is divided into the four parts HH, HL, LH, and LL and the further the approximation part is divided into two sub-bands. Approximation part is LL. And the other part is detailed part in which we have all three parts HH, HL and LH. We will work on the detailed part because the noise will occur on the high frequency part which is detailed part.

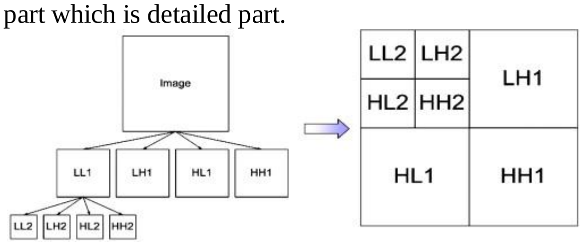

FIG: Two level image thresholding decomposition by using DWT [10]

DWT is used to reduce the speckle noise from the image. It has three steps which are given below:

1. Calculate the DWT of the image.
2. Threshold the wave coefficients.
3. Compute the IDWT to get the denoised image.

Two types of thresholding functions are there soft and hard thresholding. Soft thresholding reduces or deletes the high frequency components in which speckle noise is present but it also loses some needed information. Soft thresholding function described as follow:

n2 (w) = (w-sgn(w)T)I(w|w|>T)

Where sgn (x) is the sign function of x. The soft thresholding is preferred over the hard thresholding rule.

Hard thresholding reduces or deletes the low frequency components which also lose the some necessary information. Hard thresholding is described as follow: n1 (w) =wI (|w|>T) where w is a wavelet coefficient, T is the threshold [1][3][11].In this thesis I have done my work with using DWT+Wiener filter and with using the wavelets. I have compared my proposed work results with other traditional filters such as: wiener filter, median filter, homomorphic median filter and with homomorphic wiener filter. But my proposed work gives the better result than the all other traditional filter which is compared as follow with the different different standard deviations.

STEPS OF PROPOSED METHODOLOGY:

1. Load the input image of size [m n] where m=n=128,256,512,1024.

2. Add the noise into an image by using standard mat lab function im noise.

3. Apply log transformation to the input noisy image or apply homorphic filtering approaches to the input noisy image.

g(x,y)=f(x,y).ɳ(x,y)

Where f(x,y)=input noise free image.

ɳ(x, y) =noise corrupted image

Then by homomorphic filtering .take the logarithm on above equations

Log [f(x, y).ɳ(x, y)]

z(x,y)=log f(x,y)+logɳ(x,y).

4. Apply DWT (Discrete wavelet transform) on z^(x, y) =log f(x, y) +logɳ(x, y) to decomposed the image into detail part + approximation part using equations.

5. Now find the variance of each sub band by using the equation:

Var=median (median (HH)', 1)/0.6745;

Which is also known as MAD (Median absolute deviation method) given by David l.donoho

6. Threshold the each sub band by calculating the threshold computing by the following formula:

$$\text{Threshold}=\frac{c*MAD-Q}{2}$$

Where MAD is given by step 5

C=Decomposition of wavelet at level 2.

Q=abs (M-I)

Where M is calculated by applying wiener filtering on each band sub band(H,V,D,HL,LH,HH) on [3 3],[5 5] and [7 7] window. And I is calculated by taking the only positive value of each sub band.

7. After apply soft thresholding technique we should take inverse discrete wavelet transform to the modified wavelet coefficient by using the following formula: VAR=median (median (H)', 1)/0.6745;

c=2^ (N-1);
TH=c*VAR-QQ/2;

8. After take the inverse wavelet transform of the wavelet coefficient we should applying wiener filtering on the denoised image to get the further improved result.

9. Finally take the exponential of about output to get the final denoised image.

10. Finally calculate its PSNR value of denoised image by the following formula.

$$\text{MSE}=\frac{1}{MN}\left[\sum\sum(f(x,y-f'(x,y))\right]$$

$$\text{PSNR}=10*\log10\left(\frac{255*255}{MSE}\right)$$

IV.Results and Conclusion:

[3 3] window table using db wavelet family:

σ / filters	0.1	0.2	0.3	0.4	0.5
W.F	30.703	28.320	26.775	25.674	24.834
M.F	28.380	26.403	25.152	24.112	23.389
H.M.F	28.381	26.425	25.064	24.147	23.306
H.W.F	29.560	28.239	27.225	26.390	25.647
DWT+ W.F	33.307	32.275	31.415	30.821	30.214

In the above table it shows the results of standard [3 3] window using Daubechies wavelet family. In this table we conclude that the wiener filter is better than the other non wavelet filters such as: median filter, homomorphic wiener filter, homomorphic median filter. But in some case wiener filter gives the worse results than the homomorphic filter when you add the high quantity of noise in it such as 0.3,0.4 and 0.5.but our proposed method is much better than all of these traditional filters. Our proposed filter is DWT+Wiener filter. It shows the better result than all of the other traditional filters such as: wiener filter, median filter, homomorphic median filter and homomorphic wiener filter. It does not give the worse results when you add when the high quantity of speckle noise occurred in the image. In the above table W.F mean wiener filter, M.F mean median filter,H.W.F mean homomorphic wiener filter and H.M.F mean homomorphic median filter.DWT mean discrete wavelet transform + wiener filter which is our proposed method to denoised the image from the speckle noise. Which give the best from all of them which are used in the above table. It shows the Daubechies wavelet using results.

[3 3] window table using haar family wavelet:

σ / Filters	0.1	0.2	0.3	0.4	0.5
W.F	30.703	28.320	26.775	25.678	24.834
M.F	28.380	26.403	25.159	24.117	23.393
H.M.F	28.381	26.425	25.164	24.147	23.316
H.W.F	29.560	28.239	27.225	26.390	25.647
DWT +W.F	33.306	32.273	31.414	30.823	30.216

In the above table it shows the results of standard [3 3] window using haar wavelet family. In this table we conclude that the wiener filter is better than the other non wavelet filters such as: median filter, homomorphic wiener filter, homomorphic median filter. But in some case wiener filter gives the worse results than the homomorphic filter when you add the high quantity of noise in it such as 0.3, 0.4 and 0.5.but our proposed method is much better than all of these traditional filters. Our traditional filter is DWT+Wiener filter. It shows the better result than all of the other traditional filters such as: wiener filter, median filter, homomorphic median filter and homomorphic wiener filter does not gives the worse results when you add when the high quantity of speckle noise occurred in the image it gives the better results at any stage of noise. In the above table W.F mean wiener filter and M.F mean median filter. In the above case Haar wavelet using filters gives the better result than when you use the window[3 3] but it gives the worse result than the db wavelet when you use the [5 5] window instead of [3 3] window.

A. Image result for wiener filter [3 3] window:

These are the following results for when we use the wiener filter for denoising the image

(a) Input image leena (b) Noisy image $\sigma = 0.02)$ (c) Weiner filter (Denoised)

In the above case of wiener filter when we added the speckle noise of s.d 0.02 then it becomes the second (b) noisy image then we will apply the wiener filter on it then it denoised the noisy image and gives the better result or gives the image clear and least blurred. It gives the **28.3209 PSNR** values it shows that how much image is denoised.

B.Results for median filter using window [3 3] with s.d 0.02:

(a) Input leena image (b) Noisy image σ= 0.02 (c) Median filter (Denoised)

In the above case of median filter when we added the speckle noise of s.d 0.02 then it becomes the second (b) noisy image then we will apply the median filter on it then it denoised the noisy image and gives the better result or gives the image clear and least blurred. It gives the **26.4037 PSNR** values it shows that how much image is denoised..

C. [3 3] window using results of Homomorphic median filter:

(a) Input image leena (b) Noisy image σ=0.02 (c) Homomorphic (M.F) Denoised

In the above case of median filter when we added the speckle noise of s.d 0.02 then it becomes the second (b) noisy image then we will apply the median filter on it then it denoised the noisy image and gives the image unclear and least blurred. It gives the **26.4253 PSNR**

D. Image results for homomorphic wiener filter using window[3 3]:

(a) Input noisy image leena (b) Noisy image σ= 0.02 (c) Homomorphic (W.F) Denoised. Fig (5.4.1.1)

In the above case of homomorphic wiener filter when we added the speckle noise of s.d 0.02 then it becomes the second (b) noisy image then we will apply the homomorphic wiener filter on it then it denoised the noisy image and gives the image unclear and least blurred. It gives the **28.2672 PSNR** values.

E.**(DB1 FAMILY) Image results for DWT+Wiener filter using window [3 3]**

(a) Input image leena (b) Noisy image σ= 0.02 (c) DWT+Wiener filter (Denoised)

In the above case of dwt+wiener filter it gives the **32.2738 PSNR** values it shows that how much image is denoised. PSNR value of homomorphic wiener filter is lesser then the wiener filter in window [3 3] with s.d 0.02 dwt+wiener filter is better than the wiener filter and other traditional filters. It gives the clearer and less blurred denoised image.

F. (HAAR) Image results for DWT+(W.F) using window[3 3] :

(a) Input image leena (b) Noisy image σ=0.02 (c) DWT+ (W.F) (Denoised)

In the above case of dwt+wiener filter when we added the speckle noise of s.d 0.02 then it becomes the second (b) noisy image then we will apply the median filter on it then it denoised the noisy image and gives the image unclear and least blurred. It gives the **32.2751 PSNR** values it shows that how much image is denoised. Dwt+wiener filter haar family is better than the wiener filter and other traditional filters. It gives the better results [5 5] window and dwt+wiener filter [7 7] window. It gives the clearer and less blurred denoised image then the wiener filter or others

Conclusion:

We have discussed many types of traditional filter methods. Which are specially used to denoising the noisy image through the filters. Traditional filters are such as: median filter, wiener filter, homomorphic wiener filter and homomorphic median filters. These filters are used to remove the noise from the corrupted image .wiener filter has the better result to compare with the median filter, homomorphic filters and homomorphic wiener filter but in some case like in homomorphic wiener filter if you add the high quantity of noise then the homomorphic wiener filter gives the better results than the wiener and other traditional filters. But in this proposed work we have used DWT+Wiener filter which give the better result from all of these traditional filters. It gives the better value of PSNR and gives the better picture quality and noise free noisy image with less blurred and less smoothy.Because in this filter we have used the DWT Wavelet with the wiener filter and then we apply the mean thresholding on it then after completion of it. We have used the inverse of DWT and exponential also we have used the log transform at the starting. So by these steps it becomes the better denoising filter to remove the noise from the corrupted image.

REFRENCES:

[1] S.Sudha, G.R Suresh and R.Suknesh, "Speckle Noise Reduction In Ultrasound Images Using Context-Based Adaptive Wavelet Thresholding", IETE Journal of Research Vol 55, issue 3, May-Jun 2009.

[2] D.T. Kaun, Sowchauk, T.C.Strand, P.Chavel, "Adaptive Noise Smoothing Filters for Signal Dependent Noise", IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol. PMAI-7, Page(s):165-177, 1985.

[3] S.Sudha, G.R Suresh and R.Suknesh, "Speckle Noise Reduction in Ultrasound images By Wavelet Thresholding Based on Weighted Variance", International Journal of Computer Theory and Engineering, Vol. 1, No. 1, pages 7-12, April 2009.

[4] Anil K.Jain, "Fundamentals of Digital Image Processing" Second Edition, NJ Prentice-Hall, 1989.

[5] "Median filtering"[online] http://www.cs.auckland.ac.nz

[6] "Wiener filtering"[online] http://www.owlnet.rice.edu

[7] J.S.Lee, "Refined Filtering of Image Noise Using Local Statistics", Journal of Computer Vision, Graphics and Image Processing. Vol 15, issue No.4, Page(s): 380-389, April 1981.

[8] V.S.Frost, J.A.Stiles, K.S.Shanmugam, J.C.Holtzman, "A Model for Radar Image and it's Application to Adaptive Digital Filtering for Multiplicative Noise", IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol. PMAI-4, Page(s):175-186, 1982.

[9] Jappreet Kaur, Jasdeep Kaur, Manpreet Kaur."Survey of despeckling techniques for medical images."int j.comp. Tech.Appl,vol 2 (4),Pages 1003-1007,Jult-August 2011.

[10] D.Gnanadurai, V.Sadasivam, "An Efficient Adaptive Thresholding Technique For wavelet Based Image Denoising" International Journal of Signal Processing, Vol 2. Page(s):114-119, 2006."

[11] Denvor,Fodor I.K, Kamarth C, "Denoising Through Wavelet Shrinkage", An Emperical Study, Journal of Electronic Imaging 12, Page(s):151-160, 2003