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A Novel approach for the Reduction of Noise

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Abstract*— Most of the current speckle reduction system uses various filters .There are various filters for reducing the speckle noise reduction. But due to some drawbacks these traditional filters cannot remove speckle noise efficiently. So a hybrid technique speckle noise reduction using anisotropic filter based on wavelets is used. In this paper the necessary idea of an uncorrupted image from the noisy image is identified as "denoising". Choosing the most excellent way plays a very important role for getting the desired image. So in this thesis report a study is made on "Speckle Noise reduction using anisotropic filter based on wavelets". There are various existing techniques to remove the speckle noise reduction but due to some drawbacks these techniques cannot remove speckle noise efficiently. The adaptive filters that are Kuan filter, Lee filter, and Frost filter are not able to remove a full removal of speckle without losing any edges because they relies on local statistical data and this statistical data depends upon window size and shape. As these existing filters are very much sensitive to the window shape and window size. If the window shape is very much larger then over smoothing will occurs. As the size of window is smaller than the smoothing ability of the window will reduce. So to overcome these limitations, a new hybrid technique that combines wavelet based denoising and anisotropic diffusion filter is proposed. Wavelet is dependent on both frequency and time domain. It is frame based approach. It provides better resolution and it does not depend upon the window size. In addition the anisotropic filter is based on partial differential equation approach.

I. INTRODUCTION

An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y, and the amplitude values of f are all finite, discrete quantities, then it is known as a digital image [1].

1.1 Digital Images

It is a technique to convert the image into digital form and do a number of operations applied on it to obtain better image or to get meaningful information. Thus the various operations have been operated once an image has been digitized. Once an image has been digitized various operations can be applied for improving the quality and removing the blurredness. Noise is an unwanted signal which can corrupt the real signals and some dots appeared in the image. On television screens, random black and white snow-like patterns can be seen on loss of reception. Both videos and images noise corrupts. So the main motive of denoising is to remove a noise. A noisy image is not pleasant to view so image denoising is needed. With the noise, some fine details in the image may be confused. To work effectively many image-processing algorithms such as pattern recognition, image representation and description needs a clean image. Noise samples like random and uncorrelated are not compressible. In image and video processing such concerns underline the importance of denoising [2].

1.2 Denoising

Image denoising is an essential task in image processing, both as a component in other processes and as a process itself. Various methods are there to denoise the image. The main properties of a good image-denoising model are that it will preserve edges while removing noise [2] [3]. Linear models have been used traditionally, noisy image as input-data, i.e. a linear, 2nd order PDE (Partial differential equation) model. The most common approach is to solving the heat equation or use a Gaussian filter. So this type of denoising is acceptable. Speed is one of the major advantages of linear noise models. Due to some disadvantages of linear model is that they are unable to preserve edges in an exceedingly sensible manner: that are shown as discontinuities within the image. On the other hand, Non-linear models will handle edges in an exceedingly far better approach than linear models. For non-linear image denoising

Total Variation (TV) filter is commonly used to denoise the nonlinear images. It will conserve the edges in very good manner. Another method is to combine a fourth order and second order approach. By the 4th order scheme smooth regions are filtered, by a 2nd order scheme while edges are filtered. One has to construct a weight function to choose in which areas of the image each of the models are to be used [3].

1.3 Noise

Each imaging system suffers with a common problem of "Noise". Unwanted data which may reduce the contrast deteriorating the shape or size of an object in an image and blurring of edges or dilution of fine details in the image may be termed as noise.
Noise may occur due to the following reasons [4]:

i. Due to structure of the system
ii. Due to image captured devices
iii. Due to the Illumination Condition
iv. Mechanism which is used for acquiring image

Primary Random Noise, Fixed Pattern and Banding are three types of Noise. Random Noise revolves around an increase in intensity of the picture. It occurs through color discrepancies above and below where the intensity changes. It is random, because even if the same settings are used, the noise occurs randomly throughout the image. It is generally affected by exposure length. Random noise is the hardest to get rid of because it cannot predict where it will occur. The digital camera itself cannot account for it, and it has to be lessened in an image editing program [5].
Fixed pattern noise surrounds hot pixels. Hot pixels are pixel bits that are more intense than others surrounding it and are much brighter than random noise fluctuations. Long exposures and high temperatures cause fixed pattern noise to appear. If pictures are taken under the same settings, the hot pixels will occur in the same place and time. Fixed pattern noise is the easiest type to fix after the fact. Once a digital camera realizes the fixed pattern, it can be adjusted to lessen the effects on the image. However, it can be more dubious to the eye than random noise if not lessened [5].
Banding noise depends on the camera as not all digital cameras will create it. During the digital processing steps, the digital camera takes the data being produced from the sensor and creates the noise from that. High speeds, shadows and photo brightening will create banding noise. Gaussian noise, salt & pepper noise, passion noise, and speckle noise are some of the examples of noise [5].

1.3.1 Noise Source

Various sources of noise are:

i. Through capturing a picture movement of camera.
ii. Due to the addition of temperature.
iii. Due to the bit errors in image communication.
iv. Scratching in an image.
v. Due to lens abnormality.

1.3.2 Types of Noise

Impulse Noise: Impulse Noise is categorized as unwanted, instantaneous sharp clicks in image. This kind of noise is caused by electromagnetic inference or ill synchronization recording of digital images. This category of noise is well known as Salt and Pepper noise [6].
Gaussian Noise: It is statistical type of noise. It is based on Probability density function and this probability density function is always equal to normal distribution. There are specific types of filters used for Gaussian noise reduction such as spatial filter, in an image when smoothing occurs undesirable results may occur in the blurring of fine-scaled image edges and details due to the blockage of high frequencies [6].
Additive White Gaussian Noise:
Additive White Gaussian Noise **(**AWGN) is a model which is based on information theory to copy the effect of many processes that occur in our environment. The characteristics are as follows:

i. 'Additive' to the information system it is added to any noise that might be intrinsic.
ii. 'White' as power is uniform across the frequency band for any information system. White color indicates uniform emissions in the visible spectrum for all frequencies.
iii. 'Gaussian' expresses an average value of zero within time domain in the normal distribution [6].

Shot Noise: One of the most important types of electronic noise is shot noise which originates from the electric charge. This type of noise is added during time of capturing of an image [6].

$$\text{S} = v_{qn}\, sqrt(12) \qquad \text{………….......... (1.1)}$$

In this equation, S is the shot noise, v_{qn} is the square root of the capturing image.
Quantization Noise (Q): The difference between input and output is named the quantization error. Therefore, the quantization error can be between -1/2Q and +1/2Q. This error can be considered a quantization noise with RMS: It can be calculated by dividing the range of the ADC by the number of steps in the staircase [6]

$$Q = \frac{V_{ref}}{2^N} \qquad \text{………………… (1.2)}$$

In this equation, where N is the number of bits of the ADC and the input range can be somewhere between 0 and V_ref , where ADC is Analog-Digital-Converter.
Anisotropic Noise: This type of noise is occurred when image is captured at oblique viewing angles with the projected camera. For removal of anisotropic noise, filter used is anisotropic filter which reduces and preserves details at extreme viewing angles [6].
Multiplicative Noise: It is unwanted random signal that gets multiplied into some relevant signal during capture, transmission, or other processing examples of multiplicative noise affecting digital photographs, in the lens dark spots caused by dust and image [6].

1.4 Speckle Noise

Speckle is a 'noise' which reduces the quality of the Ultrasound images and synthetic aperture radar (SAR) images. For image interpretation difficulties, speckle noise is more serious problem in SAR images. From multiple distributed targets, the major cause of speckle noise is the backscattered signals which are due to the coherent processing [5] [6].It depends upon different mathematical conditions or methods to reduce the speckle. One method, for example, employs multiple-look processing), averaging out the speckle noise by taking several "looks" at a target in a single radar sweep. The average is the incoherent average of the looks. Second method consists of adaptive and non-adaptive filters. Adaptive filters adapt their weightings across the image to the speckle level. For non-adaptive filters it matches the same weights over the entire image. So this type of filtering also removes actual image information and high-frequency information. The adaptive filter is having the capability to preserve edges in better manner. Whereas non-adaptive filtering requires less computational power and is simpler to implement. Non-adaptive speckle filtering consists of two methods: one method is based on the median and another method is based upon the mean. This non adaptive filtering is having better capability to preserve edges as compared to adaptive filters while removing noise spikes [6]. There are various adaptive filtering methods for removal of Speckle Noise such as Frost filter, Lee filter, and the R-MAP filter. Based upon their mathematical models it depends upon these fundamental assumptions [5] [6].

i. Speckle is a multiplicative noise.
ii. The two forms of speckle noise are: first is signal and another is noise. Both of these are independent on each other.

Speckle is a noise variation in contrast. But it is not a noise in an image. From an object it occurs randomly through backscattered waves and it mostly occurs in Ultrasound imaging and synthetic aperture radar imaging. Additive Noise is the one which can be removed or reduced very easily and it is systematic in nature. Whereas multiplicative noise is the one which cannot be removed very easily, due to the de-phased echoes from the appeared scatters, multiplicative noise is generated and is termed as “Speckle Noise” [5] [6] [7] .It seems to be as noise but it contains some useful information because it is due to the surroundings of the target. In different imaging systems speckle may appear distinct because of the formation of image under coherent waves. When an ultrasound wave pulse arbitrarily attracts the particle or objects that is comparable to sound wavelength, it generates diffuse scattering which is termed as “Speckle Noise”. Ultrasound Images and SAR images is an inherent property of Speckle Noise. To improve image quality it is based on two applications, which are as follows [5] [6] [7] [8].

i. Auto Segmentation
ii. Enhancing Visualization

For enhancement of visualization of speckle images many filters were developed. Their main applications are in two areas: SAR and Ultrasound images. Ultrasound is very famous in Medical imaging, because of its low cost, real time system, small in size and less harmful to human body. But the major disadvantage is the presence of speckle. In Figure 1.1 synthetic camera man image is taken with different standard deviations.

Figure1.1 (a) Cameraman original synthetic image [9]

Figure1.1(b) Noisy Image 0.5 Deviation

Figure1.1(c) Noisy Image 0.75 Deviation

Figure 1.1 Image Corrupted with Speckle Noise With different Standard deviations (σ) of noise (a) Original Synthetic Image without Noise. (b) Synthetic Image having speckle noise whose Standard deviation is 0.5 (c) Synthetic Image having speckle noise whose Standard deviation is 0.75 [8].

II. LITERATURE REVIEW

F. Jin et al. [16] proposed a new hybrid technique which combines both spatial filtering and transform methods that are adaptive weighting wiener filter and discrete wavelet transform is applied to the noisy images. The results shows that proposed filter gives better results in terms of (PSNR) peak signal to noise ratio.

Hua Zhong [17] proposed a new hybrid technique which is based on non local filter and lee filter. As this technique provides better image smoothing and preserving the edges and provides a balance between structure similarity and homogeneity similarity. Experimental results show that proposed filter gives better results than other existing techniques.

Fan Zhang et al. [18] proposed a method for ultrasound imaging which is based on nonlinear diffusion technique. With this technique filtering of band pass ultrasound images in Laplacian pyramid domain speckle is removed. In every pyramid layer, a nonlinear diffusion grade threshold is mechanically set by a difference of middle absolute deviation (MAD) estimator. The results show that proposed method has better results than other reduction methods.

Yuan Gao and Zhengyao Bai [2] proposed a speckle reduction method which is based on curve let domain in SAR images. In this technique, curve let transform is mapped with wavelet filtering. In the first step, multiplicative noise is converted in to additive noise. Second step is to compute the threshold, by using soft and hard thresholding curve let coefficients are threshold. Lastly, opposite CT and exponential transform are applied to reconstruct the original image. This shows that this method is better than other filtering techniques.

S.Sudha et al. [3] proposed a thresholding scheme for noise reduction in ultrasound images. The comparison shows that the proposed technique provides better results than other existing techniques.

Pierrick Coupe et al. [19] proposed a Bayesian thresholding and NL-means filter in Ultrasound images. Quantitative results on synthetic images show the performances of the proposed method compared to other methods. Results of proposed method give better than other Speckle reduction methods.

Raman Maini and Himanshu Aggarwal [13] proposed and compare different speckle reduction filters. The results have been presented by filtered images, arithmetical tables and diagram. Finally, experimental results show that it gives better results in terms of PSNR.

Bibo Lu [20] proposed a novel SAR speckle reduction method base on nonlocal means (NLM) filter. In this firstly convert the multiplicative noise into additive noise by taking the logarithm. The proposed method can save edges and fine details. Speckle SAR images have been taken and also been compared with our methods.

Shamsoddini and J.C.Trinder [21] proposed a new technique which is based on enhanced lee and Gamma Map filters which gives better results for smoothing the image and which gives better results for spatial resolution. The previous filters like lee, kuan these will not preserve the edges due to the coherent nature of the waves and it decreases the speckle level. So the proposed technique gives better results in terms of ENL (Equivalent Number of looks) Coefficient of Correlation and EEI (edge enhancing index).

Udomhunskal and Wongsita [10] proposed a method for Ultrasonic speckle denoising using the hybrid technique which is based on wavelet transform and wiener filter to reduce the speckle noise while preserving the details. In this method, firstly apply the 2D discrete wavelet transform for the noisy image. Then, the wiener filter is applied to each detail subband. Than the experimental results, found that this method gives better results for removal of ultrasonic speckle denoising.

S.Mohamed et al. [22] proposed an algorithm for removal of speckle noise using Particle Swarm Optimization (PSO) technique is presented. Firstly applied the Modified Hybrid median filter to reduce speckle noise in the distorted images, then diagonal elements of the median can be calculated and then finally the two values are compared with the central pixel value. The performance of the algorithm is tested and compared with these different types of filters. Experimental results show that the proposed method gives better results than other methods.

J. Umamaheswari and G. Radhamani [23] proposed a new hybridization technique which is based on wavelet thresholding and median filter is used to reduce the speckle noise and salt and pepper noise. In this paper dicom brain image is used. The results are calculated in terms of peak signal noise ratio, Mean square error, and elapsed time.

Manish Goyal and Gianetan Singh Sekhon [4] proposed wavelet based hybrid thresholding techniques: firstly apply the statistical method and second technique based on bayes threshold. And then results are calculated. And then apply threshold for soft thresholding. For post processing wiener filter is used. Experimental results show that proposed filter gives better results.

Agrawal et al. [26] proposed a new technique which is based on discrete wavelet transform. Discrete wavelet transform is used to provide the image better resolution. In this paper magnetic resonance imaging is taken to denoise the image. Experimental results show that the proposed technique gives better results in terms of peak signal to noise ratio.

Roopa Ahirwar and Abhishek Choubey [25] proposed different filtering techniques for the removal of speckle noise. The results of the images is calculated by following parameters: Mean Square Error (MSE), Noise Variance, Signal-to-Noise Ratio (SNR), Peak Signal-to-Noise Ratio (PSNR) and Equivalent Numbers of Looks (ENL).

Karthikeyan and Chandrasekhar [15] proposed a hybrid technique which combines fourth order PDE based anisotropic diffusion, and wavelet based Bayesshrink technique. The proposed filter is compared with traditional filters and existing filters. The proposed method is efficient than other methods than other existing techniques.

Agrawal and Venugopalan [24] proposed a different methods such as median, Lee and Wiener2 filters for the sampled SAR images and compare their performance statistically by analyze quality parameters like data mean, standard deviation, kurtosis and skewness.

Zain et al. [27] proposed different types of wavelets. Wavelets provide better resolution and enhance the image. There are different types of wavelets such as biorthogonal wavelets, Daubechies wavelets, and haar wavelets. Results shows that Daubechies wavelets give better results than other types of wavelets. Comparison should be done in terms of peak signal to noise ratio.

Njeh et al. [14] proposed a new technique which is based on speckle reduction anisotropic diffusion using unsharp median for speckle noise reduction. In this ultrasound breast images is taken for speckle noise reduction. A comparative study is made on these proposed techniques. The experimental results shows that proposed technique gives better results than other techniques.

Bala Prakash et al. [7] proposed a new technique which is independently select the filter for different types of images. In this technique a new independent filter will automatically check which filter gives better results in synthetic images, real time images, and photographic images. The results are computed through different parameters. The experimental results shows that proposed technique gives better results than other techniques.

Balasubramanian et al. [28] proposed a combination of three filtering techniques that is Wavelet thresholding; bilateral filt ering and median filtering are the three different filters in our hybrid technique which performs the different Results in terms of PSNR and edge preservation.

Mashaly et al. [8] proposed a new technique which is based on morphological operations. In this paper Synthetic aperture radar images will be taken. In this firstly morphological operations will be applied to remove the speckle noise reduction and the results are compared with different filtering techniques such as adaptive and non adaptive filters.

Santhanamari et al. [29] proposed a dual-tree complex wavelet transform (DTCWT) based which combines fourth order Partial Diffusion Equation (PDE) and adaptive thresholding for Gaussian noise corrupted images. In the proposed algorithm the fourth order PDE technique is applied on the detail sub band and the adaptive Thresholding is applied to the rough subband tested on Gaussian noise corrupted images. The Experimental results shows that it gives better results in terms of PSNR and SSIM than the other existing techniques.

Eveline Pregitha [30] proposed a method in Ultrasound fetal images to evaluate and calculate the performance of different filters for speckle noise .Out of established filters; Adaptive Shock filter gives better results in terms of Peak Signal to Noise Ratio and Mean Square Error.

Radek Benes and Kamil Riha [31] proposed on the issue of speckle noise and its suppression. Firstly, the multiplicative speckle noise model and its mathematical formulation are introduced. Then, certain de-noising methods are described together with possible improvements. On their basis, an improvement of Kuan method is proposed. Performance of proposed method is tested on ultrasound images and synthetic images corrupted with speckle noise. PSNR, edge preservation, standard deviation of homogenous regions and SIR are used for the evaluation of quality of noise suppression.

Adib Akl and Charles Yaacoub [9] proposed a novel technique for image despeckling that combines wavelet denoising and an enhanced adaptive version of the old Kuan filter, which results in a significant gain with respect to speckle noise filters and the simple wavelet denoising techniques. The results are evaluated in terms of peak signal to noise ratio, equivalent no of looks and coefficient of correlation.

Zeinab A.Mustafa et al. [33] proposed a hybrid median filter for noise reduction, firstly calculates the median and mean of the diagonal elements, horizontal and vertical elements in a moving window. Thus the median of the two values will be the new pixel value. The results show that our hybrid proposed method performs better in terms of denoising quality.

M. Sifuzzaman et al. [12] proposed some applications of wavelet such as data compression, recording of a sound signal, music signal, and fingerprint verification with the help of a wavelet transform. And also tried to comparative discussion of Fourier transform and wavelet transform mentioning the drawback of Fourier transform, finally, wavelet transform is a reliable and better technique than that of Fourier transforms technique

Banazier et al. [34] proposed a new hybrid technique which is based on total variation filter and wavelet thresholding is applied. In wavelet thresholding firstly decompose the image into different bands and then thresholding is applied. Last step is to apply the total variation filter to get a reconstructed image. The results are computed in terms of peak signal to noise ratio, structural similarity index and mean square error.

Alka Vishwa and Shilpa Sharma [35] proposed a new technique which is based on wavelet thresholding and adaptive filters. In this paper various synthetic images were taken like MRI,CT, Ultrasound,X-ray.The result shows that proposed filter gives better results in terms of PSNR and MSE.

Shibin et al. [11] proposed different filters, namely Lee, Frost, Median, and Speckle Reduction filter based on Wavelet based Soft Thresholding. Thus a relative study of these filters has been made in terms of preserve the features and edges as well as de-noising. The experimental results have been demonstrated by filtered images.

III. EXPERIMENTAL RESULTS

GUI of the proposed system (Graphical User Interface)

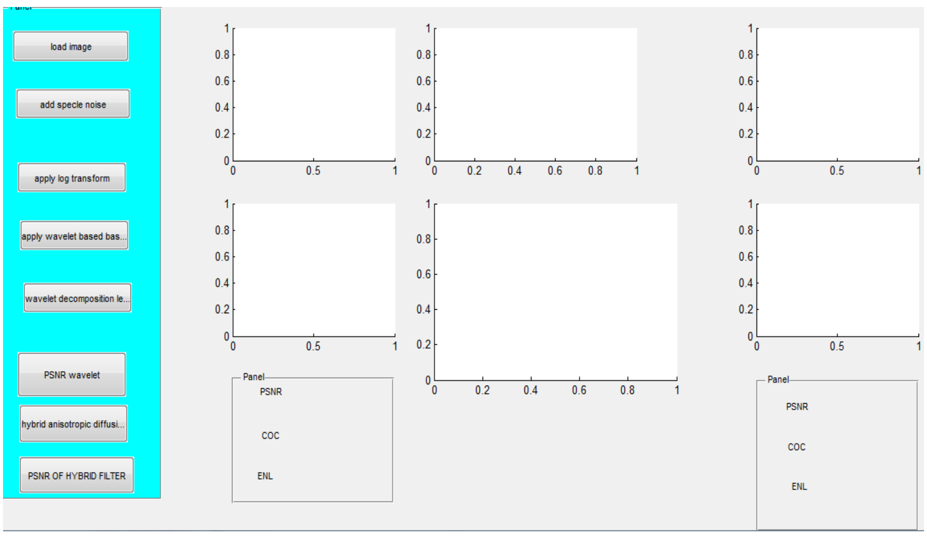

Figure 1.2 shows the GUI of the proposed system.

Within this graphical user interface it consists of different types of buttons. The first button is to load the image. When click on load image than it will display the image on right side with axis handle one. Then second one is to add the speckle noise than it will display the image on right side axis handle two. Then third is to apply the log transformation and it display the image on axis handle three. Then fourth is to apply the simple wavelet based thresholding and it displays on axis handle fourth. Then fifth is to decompose the image on 2D wavelet transform and it display the image on axis handle five. Then apply the hybrid technique using anisotropic diffusion filter and the final result will display on axis handle six and results are evaluate in terms of peak signal to noise ratio, Coefficient of correlation and Equivalent number of looks.

3.1 Test Image 1

In Figure 1.2 [9] load the image that is lena.jpg. In Figure 1.3(b), the speckle noise is added onto the original image by taking into account the intensity values of the pixels and the variance of the noise. The speckle noise is added in the following manner:

I = imnoise (I,' speckle', v) ……………… (3.1)

Where *I* stand for intensity value of the pixels and *v* is the variance of the noise

Figure 1.3(a) Original Lena image

Figure 1.3(b) Add Speckle Noise

In Figure 1.3 (c) Apply Log Transformation. As speckle noise is multiplicative noise, so to convert the multiplicative noise into additive noise the log transform is applied. It is used to expand the dark values of the pixels in an image and compress the higher values of the pixels. With large variations in the pixel values it compresses the dynamic range of the image. The log transformations can be defined by the formula [4].

s = c log(r + 1) ………………. (3.2)

Where *s* and *r* are the pixel values of the output and the input image and *c* is a constant. The value 1 is added to each of the pixel value of the input image because if there is a pixel intensity of 0 in the image, then log (0) is equal to infinity. So 1 is added, to make the minimum value at least 1.

In Figure 1.3 (d) Apply the one level Wavelet transform. In this approximation image is used to smooth out the image. Using the DWT technique and applying the Bayesian wavelet thresholding is used. In wavelet baseyian thresholding only detailed subbands contains noise but it is not true. Since approximation subband also contains the noise. So our aim is to smooth the approximation image. The estimation of noise variance can be calculated by median estimator by

$$\sigma^2 = \frac{median}{0.6745} \quad \text{…………………….. (3.3)}$$

Where σ^2 is an estimation noise. It can be calculated from each subband *HH* by the robust median estimator.


Figure 1.3 (c) Log transformation

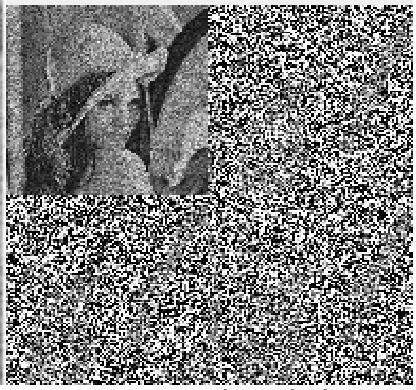
Figure 1.3 (d) Wavelet decomposition3

In Figure 1.3(f) Hybrid Anisotropic filter with wavelet based DWT technique. Here the hybrid anisotropic filter is used which provides better edge preservation and smoothens the edges. The anisotropic filter is based on partial differential equation approach. It provides better results than other existing algorithms.


Figure 1.3(e) Wavelet Reconstructed image


Figure 1.3 (f) proposed hybrid filter

3.2 Test Image 2

In Figure 5.3(a) load the image that is boat.jpg [41]. In Figure 5.3(b), the speckle noise is added onto the original image by taking into account the intensity values of the pixels and the variance of the noise. The speckle noise is added in the following manner:

I = imnoise (I,' speckle', v) ………………. (3.4)

Where *I* stand for intensity value of the pixels and *v* is the variance of the noise.


Figure 1.4(a) Original boat image

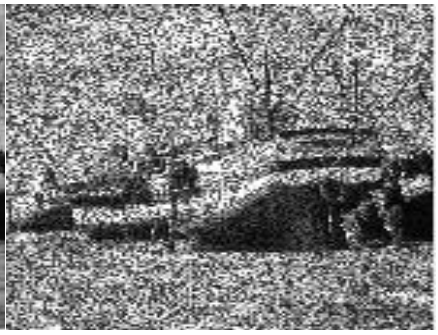
Figure 1.4(b) Add Speckle Noise

In Figure 1.4 (c) Apply Log Transformation. As speckle noise is multiplicative noise. So to convert the multiplicative noise into additive noise so log transform is applied. It is used to expand the dark values of the pixels in an image and compressed the higher values of the pixels. With large variations in the pixel values it compresses the dynamic range of the image. The log transformations can be defined by this formula [4].

$$s = c \log(r + 1) \qquad \text{……………………………….} (3.5)$$

Where s and r are the pixel values of the output and the input image and c is a constant. The value 1 is added to each of the pixel value of the input image because if there is a pixel intensity of 0 in the image, then log (0) is equal to infinity. So 1 is added, to make the minimum value at least 1.

In Figure 5.3 (d) apply the Simple Wavelet Transform. In this, the sub bands on each level are calculated. The sub bands are calculated using the formula [14].

$$\sigma^2 = \frac{median}{0.6745} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.6)$$

Where σ^2 is an estimation noise. It can be calculated from, each sub band *HH* by the robust median estimator.

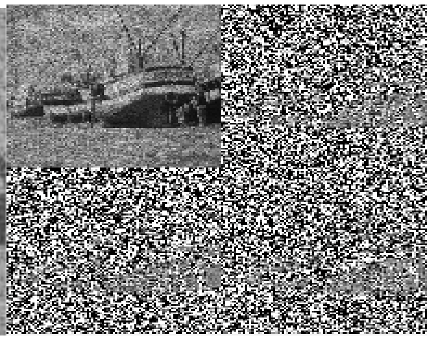

Figure 1.4(c) Log transformation

Figure 1.4(d) Wavelet decomposition

In Figure 1.4 (e) Apply 2D levels Wavelet transform. In this approximation image is used to smooth out the image. Using the DWT technique and applying the Bayesian wavelet thresholding is used. In wavelet thresholding only detailed sub bands contains noise but it is not true. Since approximation sub band also contains the noise. So our aim is to smooth the approximation image.

In Figure 1.4 (f) Hybrid Anisotropic filter with wavelet based DWT technique. Here the hybrid anisotropic filter is used which provides better edge preservation and smoothens the edges. The anisotropic filter is based on partial differential equation approach. It provides better results than other existing algorithms.

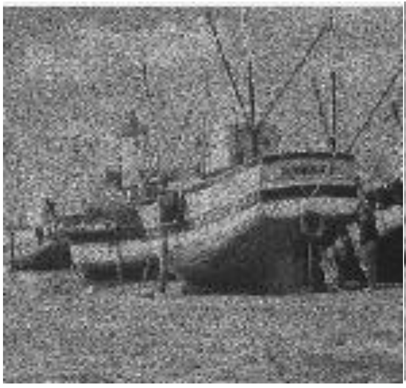

Figure 1.4 (e) Wavelet Reconstruction

Figure 1.4 (f) Proposed Hybrid Filter

IV. CONCLUSIONS

The use of image processing improves the image to the greater scope. Mostly in the speckle noise, filtering is an extremely efficient method to reduce the speckle noise in order to improve the image and provides greater efficiency There are various spatial methods and transform domain methods for removal of speckle noise reduction. Spatial filters used for filtering are kuan filter, lee filter, frost filter. These filters are not able to preserve the edges and they lie always in homogeneous areas. Because the window size of the filter is fixed. An anisotropic filter does not lie on homogeneous areas they lie in heterogeneous areas. Out of wavelet based Kuan filter a new hybrid method is used to reduce the speckle noise reduction using anisotropic filter based on wavelets provides better results than the traditional existing techniques. In our technique synthetic images were taken. As the existing filters depend upon the window size and it does not preserve the edges. So to reduce the speckle a wavelet based anisotropic filter is proposed. As wavelet is frame based approach and it does not depends upon the window size. Wavelet is localized in both space and time. It provides better resolution for approximating the signals. Wavelets are having high frequency resolution than Fourier transform. Wavelet is powerful and efficient than Fourier transform. This partial differential equation approach not conserves the edges but also enhance the edges by inhibiting diffusion across the edges and allowing diffusion on either side of the edges. Hence anisotropic diffusion is adaptive and it does not make the use of hard thresholds to modify the performance in all the same areas or in region close to edges and tiny features. This is very much edge sensitive. So the anisotropic filter provides better results in terms of Peak Signal to Noise Ratio, Coefficient of Correlation.

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