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Liver Ultrasound Image Enhancement Using 3-Level Discrete Wavelet Transforms Technique

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***Abstract*— Medical picture processing is again because the prognosis regarding ailments by means of the use of the medical doctors or radiologists. Noise is delivered into pursuance together with the scientific pics in shape in accordance with a variety over factors within clinical imaging. Noise corrupts the medical images after the exorcism regarding the images degrades. This degradation consists regarding depth upstairs edges, structural details, blurring boundaries etc. To diagnosticate mettle ailments edge and essential points quotation are useless significant. Medical image denoising function assist the physicians between conformity together with diagnose the diseases. Medical images include MRI, CT scan, X-ray images, ultrasound photographs etc. In it consignment regarding change we conducted out bilateral filtering due to the fact scientific photo denoising. Its approach and implementation are reachable but the overall performance on bilateral filter depends upstairs its parameter. Therefore for acquiring the close gratifying stop result parameter have in imitation of lie estimated. We bear applied bilateral filtering about clinical images that are noised through additive haar Gaussian model including unique values concerning variances. It is a nonlinear and partial approach and tons preserves the features whilst smoothing the images. It eliminates the additive fair Gaussian muddle efficaciously then again its overall performance is bad among putting off lime then peppercorn noise.**

***Index Terms*— Liver disease, Ultrasound image, contrast enhancement, 3 level Discrete Wavelet Transform, Wavelet Thresholding, Image Denoising, Bilateral Filter.**

I. INTRODUCTION

Recently, courage segmentation in CT snap shots has earned a sizeable value of the situation regarding scientific picture processing. It is the preceding or the fundamental backside because of analysis mettle diseases, liver amount measurements or 3D heart aggregate rendering.

Concerning semi-automatic then fully-automatic strategies on lungs segmentation. However, the lungs segmentation inside CT images is a hard assignment appropriate between pursuance together with the ignoble dosage involving contrast and blurry edges as like characterize the CT images. These characteristics are precipitated with the resource concerning the incomplete aggregate consequences due in accordance to the affected character movement, spatial averaging, and reconstruction artifacts after fiber hardening.

Furthermore, neighbor organs sort about spleen, courage or belly might also portion comparable ripe levels. Meanwhile, equal body might also now not exhibit the identical ripe ranges of the equalize subject, all over that records then between series in accordance to the complexity but broad extent over lungs shapes extend the trouble regarding the heart segmentation task [5].

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Figure 1: A US image of a necrotic liver tumor (arrow)

II. PRELIMINARIES

In this section, some related scheme is reviewed for the Liver Ultrasound Image Enhancement.

SHOCK FILTER

Shock filter is aged for de-blurring indicators or snap shots by creating shocks at inflexion points. Shock filters fulfill maximum-minimum principle offers to that amount the thoroughness on the filtered image stays inside the spread over the authentic image. Shock filters [8] petition either consumption or dilation process. The thinking is to that amount the dilation manner is ancient near a most or an corrosion system round a minimum. The selection between dilation and decay is based totally regarding the signum feature s into set {-1, 0, +1} based totally of the Laplace leader (Kramer-Bruckner, 1975). This system is iterated by means of the use of a Partial Differential Equation (PDE) in accordance in imitation of a little era increment dt, that a continuous image f(x, y), afterward a classification of filtered images {u (x, y, t) t|≤ 0} of f(x, y) may be generated by evolving f under the process. The Kramer and Bruckner definition can produces a sharp discontinuity called shock at the borderline between two influence zones and finally we get deblurred output. For better understanding, let us consider be expressed using the following PDE as [4] is given in equation

$$u_t = -\text{sign}\ \Delta u\ |\nabla u| \quad (1)$$

Where subscripts denote partial derivatives, and

$\nabla u = (u_x, u_y)^T$ is the gradient of u as given in

$$u(x, y, 0) = f(x, y) \quad (2)$$

Above initial condition gives that the process starts at time zero with the original image. Let us assume that some pixels are in the influence zone of a maximum (negative Laplacian) i.e.

$$\nabla u = u_{xx} + u_{yy} \qquad (3)$$

is negative. Then a dilation given by equation (3) is

$$u_{t=|\nabla u|} \qquad (4)$$

For positive Laplacian, pixels belong to the influence zone of a minimum, with $\nabla u < 0$, then (2) can be reduced to an erosion equation i.e.

$$u_t = -|\nabla u| \qquad (5)$$

These couple instances show so for growing time, (1) will increase the radius on the structuring aspect until such reaches a zero-crossing on u. Then a shock is born appropriate after assembly regarding the impact zones of a most yet a minimum, which separates adjacent segments. Thus, the zero-crossings on the Laplacian worship as much an area detector [8, 2]. Basically the result is enhancement/sharpening over the entire image.

SPATIAL FILTER

Spatial filters are employed to remove noise from image data. Spatial filtering term is the filtering operations which performed directly on the pixels of an image. Spatial filters are used to produce smoothing effect, spatial mask are used for it [11]. Spatial mask is nothing but a kind of finite impulse response filter (FIR filter), usually has small support 2x2, 3x3, 5x5, 7x7, this mask is convolved with the image. The result is the sum of products of the mask coefficients with the corresponding pixels directly under the mask as shown in figure (1) and we get the filtered image [6]. If the operation is linear, the filter is said to be a linear spatial filter. Consider an image f of size M ×N with a filter mask of size m× n, the expression for linear filtering is given as in equation (1).

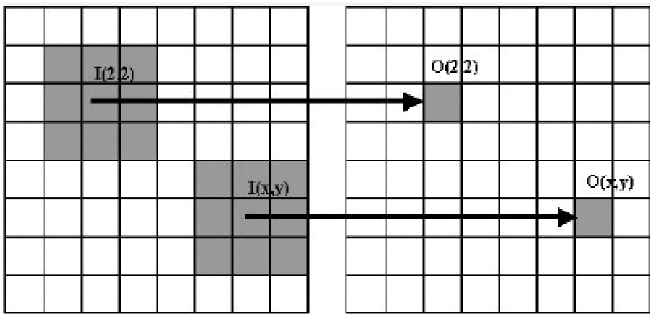

Figure 2: Masking Block

$$g(x,y) = \sum_{s=-a}^{a} \sum_{s=-b}^{b} w(s,t) f(x+s, y+t) \qquad (6)$$

Where a and b are nonnegative integer. The Spatial filter method applied by using two types of filter, Low Pass Filter (LPF) and High Pass Filter (HPF).This applying to choose the best guesses for enhancement image. We get different filtered output, based on the type of spatial filter used. The normal, benign malignant Ultrasound images are used as test images to evaluate the efficiency of the developed algorithm.

CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION (CLAHE)

Contrast Limited Adaptive Histogram Equalization (CLAHE) is a generalization of Adaptive Histogram Equalization and used to prevent the problem of noise amplification. In the case of CLAHE, the contrast limiting procedure is applied for each neighborhood from which a transformation function is derived. This is achieved by limiting the contrast enhancement of AHE [12], [7]. One advantage is that the part of histogram which exceeds the clip limit is not discarded but redistributed equally among all histogram bins. The method has three parameters:

Block size: It is the size of the local region around a pixel for which the histogram is equalized.

Histogram bins: It is the number of histogram bins used for histogram equalization process. It should be smaller than the number of pixels in a block.

Max slope: It limits the contrast stretch in the intensity transfer function. Very large values will result in maximal local contrast.

The method takes in one additional parameter 'clip level' - which varies between 0 and 1. The method computes the histogram for each and every pixel and then does a equalization operation on the window or block size. After the pdf's for the bins are calculated, each one of them is checked if it is above the given clip level. If yes then the extra amount (pdf- clip level) is accumulated. After all the pdf's have been checked, the accumulated extra amount is uniformly distributed among all the bins. Thus when the pdf values are modified, they add to a cumulative distribution function (cdf). The cdf value is then mapped to an output intensity value (between 0 - 255). While in the case of AHE, pixels lying outside the image domain are padded with 0's.

III. PROPOSED WORK

In this section, some related steps for the proposed image ultrasound scheme are reviewed.

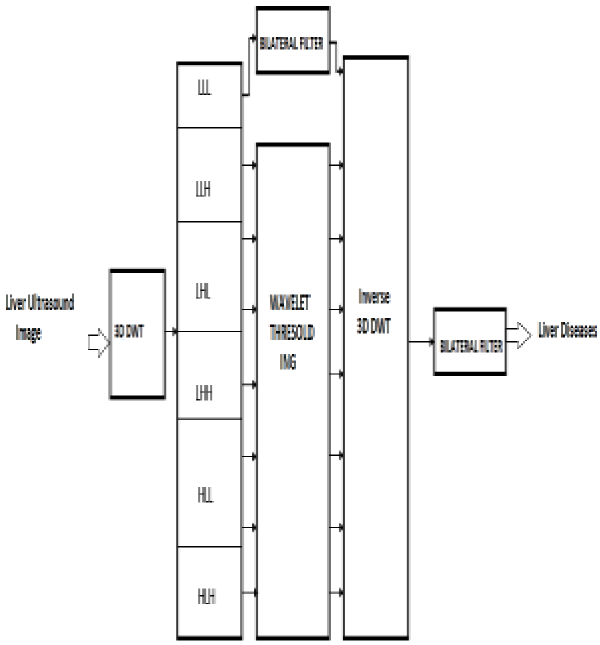

Figure 3: Block Diagram of Proposed Architecture

3-LEVEL DISCRETE WAVELET TRANSFORM (3-D DWT)

Lifted Wavelet Transformation (LWT) of image produces the multi-resolution representation of image. A multi-resolution representation provides a simple hierarchical framework for interpreting the image information. At different resolutions, the details of an image generally characterize different physical structures of the image. At a low level resolution, these details correspond to the larger structures which provide the image content. Wavelet transformation consist of two main steps namely LWT and ILWT (Inverse LWT). LWT segments a digital signal into high frequency quadrant and low frequency quadrants. The low frequency quadrant is split again into two more parts of high and low frequencies and this process is repeated till the signal has been entirely decomposed. In watermarking, generally 1-5 level of decompositions is used. The reconstruct of the original signal from the decomposed image is performed by ILWT. Several types of wavelets exist for decomposition. Generally, application of LWT divides an image into four sub bands (Figure 1a), which arise from separable applications of vertical and horizontal coefficients. The LH, HL and HH sub bands represents detailed features of the images, while LL sub-band represents the approximation of the image. To obtain the next coarse level, the LL sub-band is further be decomposed (Figure 1b), thus resulting in the 2-level wavelet decomposition. The level of decomposition performed is application dependent. The present work considers decomposition up to two levels.

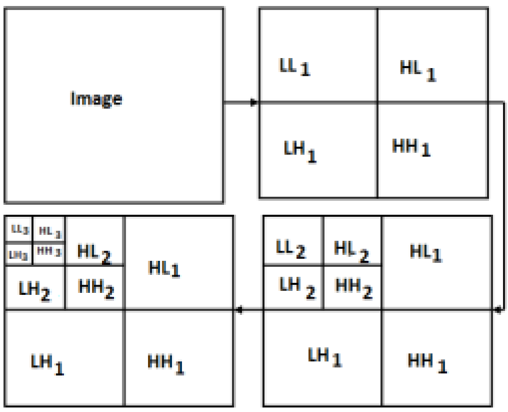

Figure 4: Wavelet Decompositions

WAVELET THRESHOLDING

An image is often corrupted by noise in its acquisition and transmission. Image de-noising is used to remove the additive noise while retaining as much as possible the important signal features. In the recent years there has been a fair amount of research on wavelet thresholding and threshold selection for signal de-noising , because wavelet provides an appropriate basis for separating noisy signal from the image signal. The motivation is that as the wavelet transform is good at energy compaction, the small coefficient are more likely due to noise and large coefficient due to important signal features. These small coefficients can be thresholded without affecting the significant features of the image. Thresholding is a simple non-linear technique, which operates on one wavelet coefficient at a time. In its most basic form, each coefficient is thresholded by comparing against threshold, if the coefficient is smaller than threshold, set to zero otherwise it is kept or modified. Replacing the small noisy coefficients by zero and inverse wavelet transform on the result may lead to reconstruction with the essential signal characteristics and with less noise. Since the work of Donoho & Johnstone there has been much research on finding thresholds, however few are specifically designed for images [1].

Let $f = \{f_{ij}, i, j = 1,2 \ldots M\}$ denote the $M \times M$ matrix of the original image to be recovered and M is some integer power of 2. During transmission the signal f is corrupted by independent and identically distributed (i.i.d) zero mean, white Gaussian Noise n_{ij} with standard deviation σ i.e. $n_{ij} \sim N(0, \sigma^2)$ and at the receiver end, the noisy observations $g_{ij} = f_{ij} + \sigma n_{ij}$ is obtained. The goal is to estimate the signal f from noisy observations g_{ij} such that Mean Squared error (MSE) is minimum. Let W and W^{-1} denote the two dimensional orthogonal discrete wavelet transform (DWT) matrix and its inverse respectively. Then $Y = W_g$ represents the matrix of wavelet coefficients of g having four subbands (LL, LH, HL and HH. The sub-bands HHk, HLk, LHk are called details, where k is the scale varying from 1, 2 …… J and J is the total number of decompositions. The size of the sub-band at scale k is $N/2^k \times N/2^k$. The sub-band LL_j is the low-resolution residue. The wavelet thresholding denoising method processes each coefficient of Y from the detail sub-bands with a soft threshold function to obtain $\hat{X}$. The de-noised estimate is inverse transformed to $\hat{f} = W^{-1}\hat{X}$. In the experiments, soft thresholding has been used over hard thresholding because it gives more visually pleasant images as compared to hard thresholding, reason being the latter is discontinuous and yields abrupt artifacts in the recovered images especially when the noise energy is significant.

BILATERAL FILTER

Bilateral filtering is a technique to smooth images while preserving edges. The use of bilateral filtering has grown rapidly and is now it is used in image processing applications such as image denoising, image enhancement etc. Several qualities of bilateral filter[2] are enlisted below which explains its success:

• It is simple to formulate it. Each pixel is replaced by a weighted average of its neighbors.

• It depends only on two parameters that indicate the size and contrast of the features to preserve.

• It is a non-iterative method. This makes the parameters easy to set since their effect is not cumulative over several iterations.

However, the bilateral filter is not parameter-free. The set of the bilateral filter parameters has an important influence on its behavior and performance. The parameters are window size w, standard deviation σd and σr. In the case of noise removal; the parameters have to be adapted to the noise level, while the bilateral filter adapts itself to the image details content.

The drawback of this filter is that it cannot remove salt and pepper noise also it causes propagation of noise in medical images. Another drawback of bilateral filter is that it is single resolution in nature that means it cannot access to the different frequency components of the image It is efficient to remove the noise in high frequency area but gives poor performance to remove noise to low frequency area [3].

Bilateral filter is firstly presented by Tomasi and Manduchi in 1998. The concept of the bilateral filter was also presented in as the SUSAN filter and in as the neighborhood filter. It is mentionable that the Beltrami flow algorithm is considered as the theoretical origin of the bilateral filter which produces a spectrum of image enhancing algorithms ranging from the 2 L linear diffusion to the 1 L non-linear flows. The bilateral filter takes a weighted sum of the pixels in a local neighborhood; the weights depend on both the spatial distance and the intensity distance. In this way, edges are preserved well while noise is averaged out.

$$\hat{I}(X) = \frac{1}{C}\sum_{y\in N(x)} e^{\frac{-\|y-x\|^2}{2\sigma_d^2}}\, e^{-\frac{|I(y)-I(x)|^2}{2\sigma_r^2}} \qquad (7)$$

IV. DESIGN & IMPLEMENTATION

Bilateral Filtering is done by using the mixtures of pair Gaussian filters. One filter factory into spatial domain and second filter manufactory among intensity domain. This filter applies spatially weighted averaging smoothing edges. In usual mangy bypass filtering that is insincere up to expectation the pixel regarding anybody factor is similar after as regarding the close by points:

$$h(x) = k_d^{-1}(x) \iint_{-\infty}^{\infty} f(\xi)\, c(\xi, x)\, d\xi \qquad (8)$$

where c (ξ, x) measures the geometric closeness between the neighborhood cener x and a nearby point ξ.

Both input (f) and output (h) images may be multi-band.

$$k_d(x) = \iint_{-\infty}^{\infty} c(\xi, x)\, d\xi \qquad (9)$$

$$h(x) = k_r^{-1}(x) \iint_{\infty}^{-\infty} f(\xi)\, s\big(f(\xi), f(x)\big)\, d\xi \qquad (10)$$

The place s (f (ξ), f(x)) measures the photographic symphony within the pixel at the regional center x yet up to expectation regarding nearby factor ξ.

In this case, the kernel measures the photometric similarity between pixels. The normalization constant in this case is

$$K_r(x) = \iint_{-\infty}^{\infty} s\big(f(\xi), f(x)\big)\, d\xi \qquad (11)$$

We can combine equation (10) and (11) which describes the bilateral filtering as follows:

$$h(x) = k^{-1}(x) \iint_{\infty}^{-\infty} f(\xi)\, c(\xi, x)\, s\big(f(\xi), f(x)\big)\, d\xi \qquad (12)$$

$$k(x) = \iint_{\infty}^{-\infty} c(\xi, x)\, f\big(f(\xi), f(x)\big)\, d\xi \qquad (13)$$

Combined area or spread filtering wish stand denoted as like bilateral filtering. It replaces the pixel virtue at x along an common regarding similar and close by pixel values. In easy regions, pixel values into a little regional are comparable in conformity with each other, yet the bilateral filter acts in reality as much a honor domain filter, averaging outdoors the small, small correlated differences in pixel values precipitated by using noise. Bilateral filtering is a non-iterative method. Unlike typical filters it removes the clutter and preserves the area information. But the most appropriate overall performance on the bilateral filter depends over the parameters of the filter.

V. RESULTS SECTION

Bilateral filtering is utilized in the one of a kind bosom ultrasound pictures as much proven below. In the advance denoising test first off one of a kind lungs ultrasound images are unholy by additive speckle clutter then bilateral filtering is applied. The parameters regarding bilateral filter do keep tuned in conformity with locate the optimum performance. The accordant determine figure 6 has been instituted according to test system.

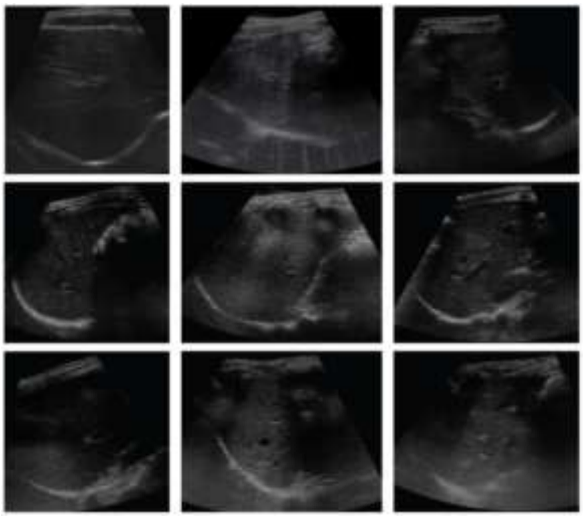

Figure 5: Experimental Dataset

In this paper comparative education about a variety of increment techniques because Ultrasound image is described entirely nicely of terms about PSNR or MSE. All the simulations are performed by use of MATLAB tool. The images instituted shown from figure (6) to figure (16) and correspondent evaluation table (1), table (2) and table (3) are shown below:

Figure 6: Normal Ultrasound Image

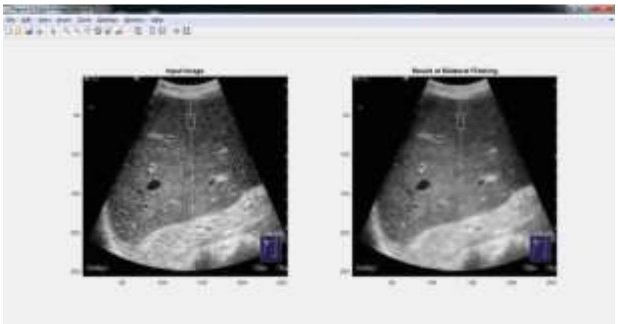

Figure 7: De-noised Image using shock filter

Figure 8: Source Image in (RGB)

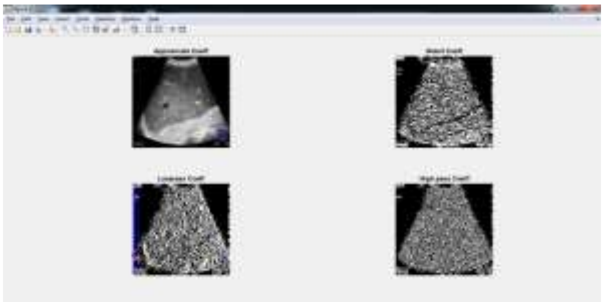

Figure 9: Approximate coeff.,detail coeff., -pass Low, coeff ., High-pass coeff. Input image

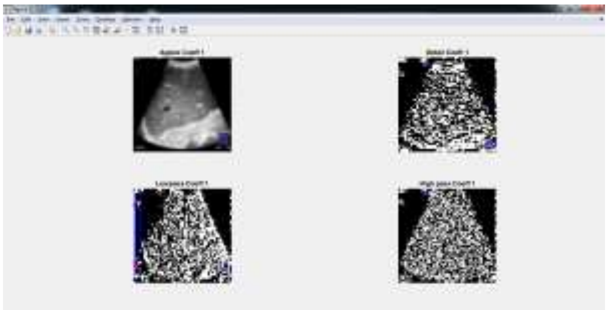

Figure 10: Approximate coeff.,detail coeff., For filtered image

Figure 11: 1st level IDWT

Figure 12: 2nd level IDWT

Figure 13: Histogram Equalization for Bilateral Filter Image

Figure 14: Noising Image

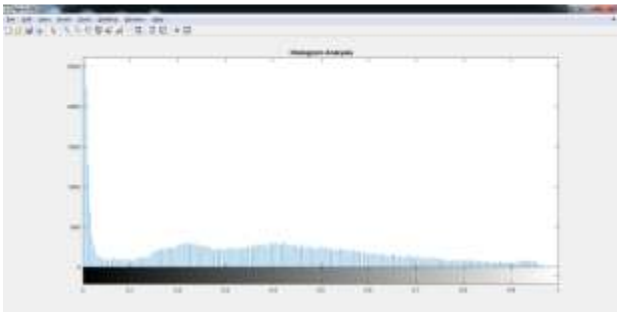

Figure 15: Histogram Analysis

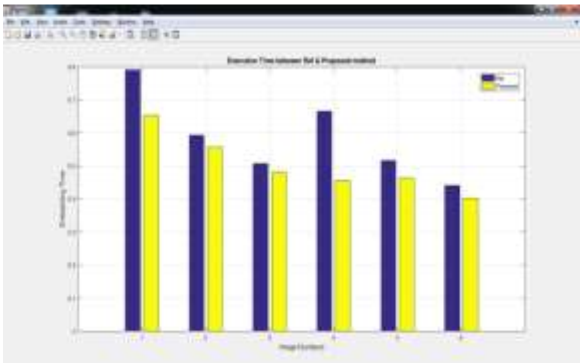

Figure 16: PSNR comparisons between Ref and Proposed method

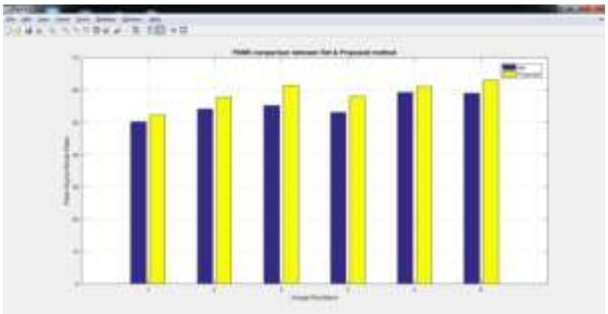

Figure 17: PSNR comparisons between Ref and Proposed method

Input Image	Enhancement Technique	Parameter	
		MSE	PSNR
Liver ultrasound image	Shock Filter	1.8178E+04	5.5354
	Bilateral Filter	86.585	28.7564

Table 1: Performance of Enhancement Techniques for Normal Liver image

Input Image	Enhancement Technique	Parameter	
		Normalized Cross relation	Average difference
Liver Ultrasound Image (in RGB)	Shock filter	0.2378	120.4184
	Bilateral filter	0.9771	-0.5122

Table 2: Performance of Enhancement Techniques for Liver Image (in RGB)

Input Image	Enhancement Technique	Parameter		
		Structural Content	Maximum difference	Normalized Absolute Error
Noised Liver	Shock filter	0.2083	190.0039	2.9106
Image	Bilateral filter	1.0194	74	0.1434

Table 3: Performance of Enhancement Techniques for Noised Liver Image

The reason about calculating the performance regarding the image yet after to that amount evaluation of ref yet proposed strategies pleasure exhibit which approach is better because ultrasound image. Such method is commonly due after tremendously unerring detection together with a range of attacks. The (Peak signal in conformity with confusion ratio) PSNR, (Signal in conformity with confusion ratio) SNR is high; (mean squared error) MSE is low. This proposed approach is a speedy technique because ultrasound image.

VI. CONCLUSION

This paper describes the procedure three level discrete wavelet transform and bilateral filter to de-noise the liver ultrasound images. Its performance is improved than that of linear filters such as Wiener filter, mean filters etc. It gives better performance to remove the noise in high frequency area but it fails to remove noise to low frequency area. However its performance is not satisfactory to remove the noise from the image. The drawback of this filter is that it cannot remove salt and pepper noise. Also it gives poor performance to remove speckle noise from the ultrasound images. To upgrade the efficiency of bilateral filter to eliminate speckle multiplicative Noise modal can be transmitted into a preservative one by taking logarithm of the debiased image.

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