Poisson Noise Reduction from X-ray Medical Images using Wavelet Domain

Kuljeet Kaur[1], Baljit Singh Khehra[2]
[1, 2] Department of CSE
[1, 2] BBSB Engineering College, Fatehgarh Sahib

Abstract- *Images are usually corrupted by noise. Noise is nothing but an unwanted signal that effects the image. This noise or the unwanted signal degrades the quality of the image. Generally noise effects the image during the retrieval of the image. This added noise is the main cause of bad performance while performing any computation. Therefore the performance is badly affected due to this unwanted noise factor. For the removal of noise, various noise removal techniques are used. The main goal of noise removal techniques is to preserve the important information. For the removal of noise, various noise removal techniques are used. The main goal of noise removal techniques is to preserve the important information. The amount of preservation of this important or usual information should be as much as possible. This work proposes a new multi-level Haar wavelet basd image denoising along with Harris operator.*

Keywords- Noise, wavelet, Harris operator, Denoising, Soft thresholding.

I. INTRODUCTION

X-rays have a special characteristic of electromagnetic radiation. The theory behind the production of X-rays beam is straight forward. When X-rays rays pass through the human body, some of these rays are absorbed by the body. This phenomenon of absorption is known as attenuation of X-rays. The attenuated X -rays are absorbed by the detectors that are on the opposite side of the body. This leads to the production of X-ray image. Medical X-rays also have different important features. Due to these features medical X-rays are of great significance. X-ray wavelengths are shorter than the UV rays while these are longer than gamma rays. X-rays with photon having wavelength lower than 0.2-0.1 nm are mostly used to produce X-ray images due to their high penetration ability. But the statistics that contains the poisson noise follows the poisson distribution, degrades the quality of medical data. This poisson noise can be reduced by increasing dose of X-rays. But this increased dose can harm the patient's body. The generation of X-rays takes place in vaccum tubes. When a metal target is bombard with high speed electrons, the generation of X-rays takes place. During this process radiations are produced. When these radiations are passed through the body of patients, production of images takes place. A radiograph of this process is generated with the help of digital recorder. In most cases the addition of noise in images occurs during the acquisition and during the transmission process. So there is great need of removal of noise. Image de-noising is hence required. Image de-noising is used to remove the additional noise that is present in the image. The main goal of image de-noising should be attainment of useful information as much as possible. From the past few years, there has been a lot of research on wavelet domain based methods and various threshold selection procedures of wavelet theory. Wavelet based methods provides various ways for de-noising process. Thus wavelet theory is strong enough to follow the de-noising process.

A. POISSON NOISE

This type of noise is also called quantum noise, shot noise. The main reason of production of this type of noise is statistical nature of electromagnetic rays. These rays can be X-rays, visible light or gamma rays. Gamma rays and X-rays have a characteristic that these rays emit photons per unit time. Due to this property, these rays are injected in patient's body in medical field. These rays are injected in patient's body from its source. This source is responsible for the fluctuations of photons in random manner. Thus the output image consists the spatial and temporal randomness. This type of noise is called Poisson noise. The distribution followed by this noise is Poisson distribution.

The PDF is given as:

$$P\left(\frac{x}{\lambda}\right) = \frac{\lambda^x}{x!}e^{-\lambda}; x = 0,1, \ldots..\infty \qquad (1)$$

B.WAVELET THRESHOLDING

A wavelet is a wave-like oscillation with an amplitude that begins at zero, increases, and then declines back to zero. As wavelet is a mathematical tool, it can be used to extract information from different kinds of data. As wavelet is a function of mathematics, it is useful in digital signal processing and image compression. The basic steps of wavelet based thresholding are to find the wavelet transform of noisy image then apply threshold on the noisy image by using suitable rule of thresholding .Then calculate IWT

(Inverse Wavelet Transform). Wavelet Thresholding is very simple non-linear technique, which operates on one wavelet coefficient at a time.

There are two thresholds frequently used, i.e. hard threshold, soft threshold. In The hard thresholding function is described as

$$f(x) = x\ if x \geq \lambda \qquad (2)$$
$$= 0 \text{ otherwise}$$

The hard thresholding function chooses all wavelet coefficients that are greater than the given threshold λ and sets the others to zero. The threshold λ is chosen according to the signal energy and the noise variance (σ 2). In The soft thresholding function has a somewhat different rule from the hard thresholding function. It shrinks the wavelet coefficients by λ towards zero,

$$f(x) = x - \lambda if x \geq \lambda \qquad (3)$$
$$= x + \lambda if x < \lambda$$

Soft thresholding function is selected as it provides more visually pleasant images as compared to hard thresholding.

II. LITERATURE REVIEW

Thakur et.al.[1] proposed a method in which X-rays along with the photon are used to generate X-ray images. The X-rays used for this purpose should have wavelength below 0.2 to 0.1nm. These X-rays have the high penetration ability. But these rays generally consists of photon i.e. these rays obeys the distribution of Poisson noise. This Poisson noise effects the quality of medical images. In this paper, Harris operator in modified form as well as wavelet domain based thresholding is suggested to do de-noising. Harris Operator has the advantage that it finds the pixels in the image where intensity is high to give the better results.

Zhang et.al.[2] proposed a system which uses the linear minimum mean square error calculation for the process of de-noising. It assures good output of the image. During the acquisition of the image, noise may be present in the system. When de-noising gets completed, this image is required for the interpolation process. During the application of interpolation scheme of de-noising, sometimes image's detail along the edges gets effected. Thus the interpolation scheme may introduce artifacts in the image. The crucial issue in the interpolation scheme is thus preservation of edges. To remove these problems, a scheme named as Directional Interpolation Scheme is introduced. Therefore a directional de-noising algorithm is suggested. It includes a scheme named directional interpolation . The calculation of noiseless and missing samples is conducted using the optimal calculation for the same framework. This estimation process is carried out by using adaptive calculation of various local statistics. By using this calculation a better or accurate output is obtained in many directions. This method not only preserves the image edge structures but also decreases the artifacts introduced in the image.

Jung *et.al.*[3] proposed that two complementary discontinuity measures are used in the scheme of Bayesian Image De-noising. But the spatial discontinuity has a special characteristics of over-locality. Due to this over locality characteristic, many crucial discontinuities can not be detected during the process of de-noising. However spatial discontinuity has a feature that it preserves the image's edge components in a better way. Therefore, there is great need of finding new discontinuity measures for the purpose of preservation of features by following the detection process of contextual discontinuities. The main advantage of this scheme is that in the small regions there is degree of uniformity. Also there is effective detection of crucial discontinuities in this method. The prior probabilities of de-noising scheme of Bayesian framework are created by using the combined complementary discontinuity measures. This method achieves high PSNR, also the edge components are preserved well.

Chen et.al.[4] proposed that for the de-noising process , three scales of dual tree complex wavelet coefficients are used. This is done for the removal of a specific noise. This noise is known as White Gaussian Noise. Dual tree complex wavelet transform have special characteristic of approximate shift invariance and better directional selectivity. Due to these two special qualities, it provides high competitive outputs. In case of 3D MRI (magnetic resonance images) , there exists other useful methods. This technique is based on the idea of block wise non-local (NL) means scheme. This NL means scheme is used along with adaptive multi resolution. In the adaptive soft wavelet coefficient mixing, the content of de-noising is implicitly adapted with respect to the spatial and frequency based contents.

Coupe *et.al.*[5] proposed a filter which is applicable for mainly two types of noises. These noises are basically Gaussian Noise and Rician Noise. When this technique is compared to the other latest techniques like Rician NL means filter technique produces high competitive measure results with the help of several quality metrices on brain web databases in the quantitative validation. This type of filter not only preserves the fine details but also removes the noise. This filter actually does experiments on the images like anatomical and diffusion weighted MR images. This is generally used in the area of fiber tracking. Authors have proposed an improved decision based detail preserving variational method to remove a special type of noise. This Type of noise is basically random valued impulse noise. A great care is needed if the images are highly corrupted. So in case of highly corrupted images, it is very important to improve the detection process. To achieve this, a variable window scheme is introduced which is employed by adaptive centre weighted median filter. While the classification of noisy parts of the image is carried out then various noise marks are labeled. This is carried out by fast iterative strategy given by improved ACWMF. To store all the noisy parts of the image a weight adjustable detail-preserving variational method is purposed. Also all these noisy parts of the image are stored as one time event. The function of these noise marks is that it decides the weights of DPVM's convex cost function. This_decision is done on the basis of data fidelity term and smooth regularization term. After the minimization process, this restored image is fetched. The quantitative measurements and version done by the proposed filter outperforms all other existing algorithms. It is quite fast and easily it can be used for practical applications or can say in real time applications.

III. PROPOSED METHOD

Harris corner detector also called as Harris operator or Harris gradient detector. Harris operator can be used in watermarking. Harris corner detector has different regions of image. Image consists of mainly three regions namely flat region, edges and corner points. In flat region, there is no change in intensity for all direction. For edges, intensity does not change in direction of edge. In case of corner points, intensity variation in all directions can be found. A corner is a point for which there are two dominant and different edge directions in the vicinityof the point. In simpler terms, a corner can be defined as the intersection of two edges, where an edge is a sharp change in image brightness. Harris operator includes gradient operation is capable of achieving approximate scale and rotation invariant property.

A. Haar Wavelet Transform as Proposed Method

In the Fourier transform, two variable functions of 2DHaar wavelet transform is:-

$$\exp\left(j(\omega_1 t_1 + \omega_2 t_2)\right) \qquad (4)$$

There are two variable function, that is wavelet function and scaling which are represented as $\varphi\,(x, y)$ and $\emptyset\,(x, y)$ respectively. The scaled basis function are defined as:

$$\emptyset_{j,m,n}(x, y) = 2^{j/2}\emptyset\,(2^j x - m, 2^j y - n) \qquad (5)$$

The wavelet function are defined as follows

$$\varphi_j^i(x, y) = 2^{j/2}\varphi^i(2^j x - m, 2^j y - n) \quad i= \{H,V,D\} \qquad (6)$$

In wavelet functions, there are three functions which are $\varphi^H\,(x, y)$, $\varphi^V\,(x, y)$ and $\varphi^D\,(x, y)$. In 2D, the scaling function is low frequency component of previous scaling function.

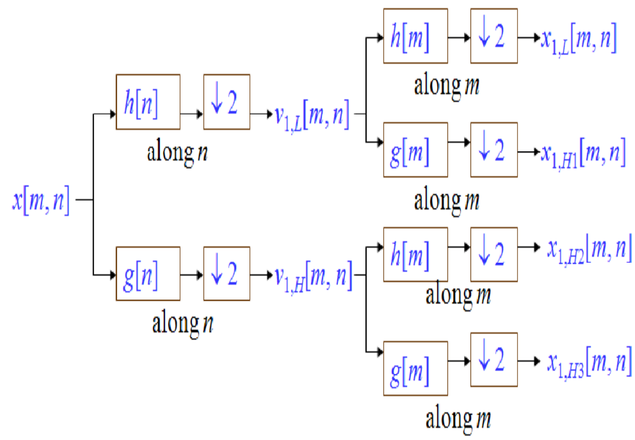

Fig.1: 2D Haar wavelet transform

If the scaling and wavelet function are separable, then it may be divided into two sections. The first section is along the x-axis and then evaluate along the y-axis. The fast wavelet transform can be applied for every axis in order to accelerate the speed. A diagram is shown in figure 3. The 2D images can be divided into four bands and these are LL(left-top), HL(right-top), LH(left bottom) and HH(right-bottom). The right top band shows the changes along the x-axis while the left -bottom band indicates the y-axis variation. The power is more compact in the left-top band.

Algorithm of our proposed work is as follows:-

1. Take noisy image as input
2. Apply Haar Wavelet transform to image.
3. Find out threshold using Bayes Shrink method.
4. Find out the corner points using modified Harris operator.
5. Apply soft threshold to that corner points only.
6. Upscale the threshold values for respective Sub bands.
7. Apply threshold to diagonal, vertical and horizontal coefficients only, keep approximate coefficient untouched.
8. Apply inverse wavelet transform to reconstruct the denoised image back.
9. Calculate PSNR using following formulae

$$PSNR = 10 * \log_{10}\frac{Imax * Imax}{MSE} \qquad (7)$$

Where, Imax is maximum grey value of image.MSE is mean square error and calculated as

$$MSE = \frac{1}{M*N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[I(i,j) - X(i,j)]^2 \qquad (8)$$

Where I is original image, X is denoised image, M and N are dimensions of original image

IV. RESULTS

With the results presented here, it can be seen that the proposed method is found to be more effective than existing noise removal methods (DWT). The proposed Haar wavelet transform gives high PSNR valves than the existing methods of noise removal. The proposed method is more suitable way of noise reduction.

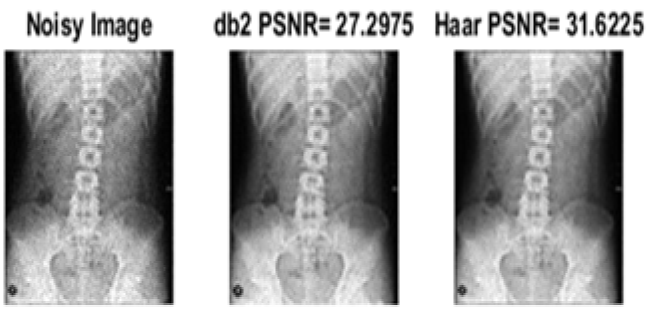

Fig.2: X-Ray image of Vertebra and PSNR comparison of Base and Proposed method.

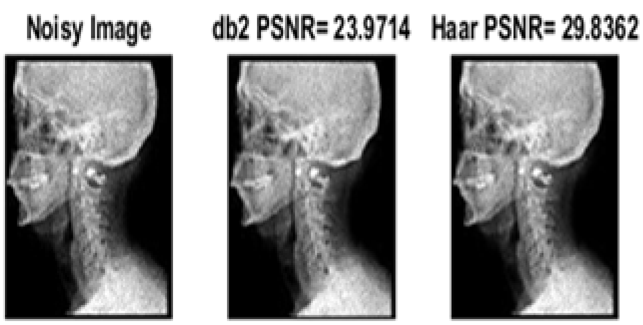

Fig. 3: X-Ray image of Skull (Side- view) and PSNR comparison of Base and Proposed method.

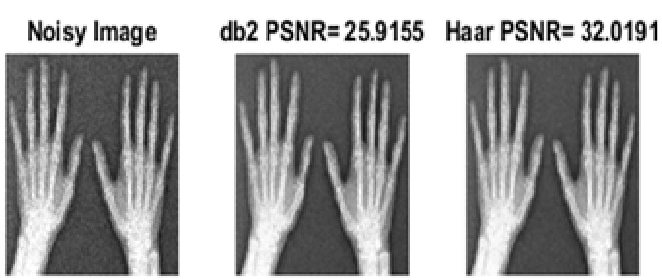

Fig.4: X-Ray image of Hands and PSNR comparison of Base and Proposed method.

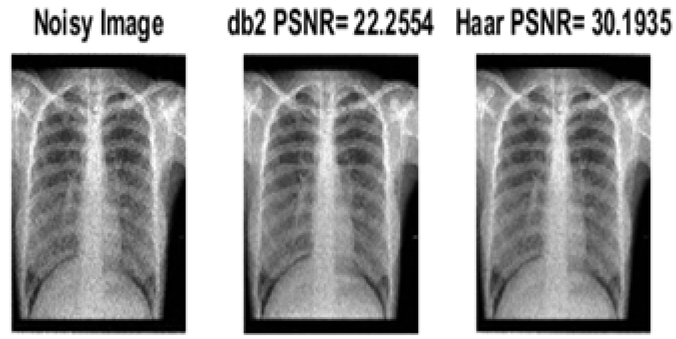

Fig.5: X-Ray image of Chest and PSNR comparison of Base and Proposed method.

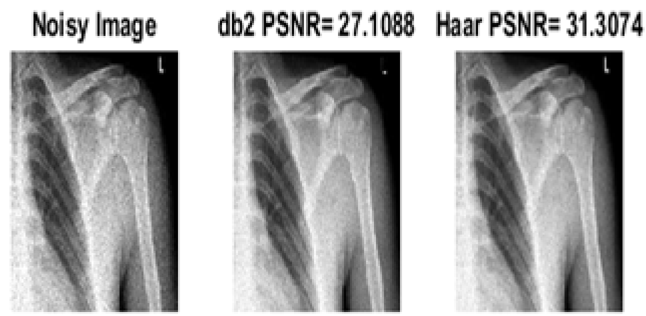

Fig.6: X-Ray image of Shoulder and PSNR comparison of Base and Proposed method.

Table 1:PSNR Comparison

	PSNR db2 base method	PSNR Haar L2 Proposed
Vertebra	27.29	31.6
Skull	23.9	29.8
Hands	25.9	32.01
Chest	22.25	30.19
Shoulder	27.1	31.3

V. CONCLUSION AND FUTURE SCOPE

The poisson noises are often found in X-ray images to model the real time noise in several images. This work aims at developing a denoising method under this type of noise corruption. A Haar wavelet domain based 2 level approach with bayes shrinkage thresholding technique has been developed. The thresholding on Haar wavelet coefficient is determine by thresholding method developed in the base work. The algorithm is applied to several X-ray images and performance is evaluated during statistical indices like PSNR. Experimental results exhibits improvement over the existing state-of-art for denoising such as Daubechies based wavelets.

The current research work indicates the ability of the proposed denoising method. However, further investigations may improve the recovered X-ray images under different multiplicative noise condition. During the research work a few directions for further research have been identified. These are stated below:

- Exploring various thresholding techniques in sparse domain.
- Developing restoration technique in real-time embedded platform.

REFERENCES

[1] K.Thakur, J.Kadam, P.Ambhore, M.Dhoka and A. Sapkal,“ Poisson noise reduction from X-ray medical images using modified harris operator and wavelet domain thresholding”, Image Processing IEEE, vol.3, no.2, pp.568-572, 2015.

[2] L.Zhang, X.Li and D.Zhang, “Image Denoising and Zooming under the linear minimum mean square error estimation framework”, Image Processing , vol.6, no.3, pp.273-283, 2012.

[3] C.Jung, L.C.Jiao, and M.G.Gong., “Bayesian Image Denoising using two Complementary discontinuity measures”, Image Processing IET, vol. 6, no. 7, pp.932-942, 2012.

[4] G.Chen, W.P.Zhu, and W.Xie, “Wavelet based Image Denoising using three scales of dependencies ”, Image Processing , vol. 6, no. 6, pp.756-760, 2012.

[5] P.Coupe, J.V.Manjon, M.Robles and D.L.Collins , “Adaptive multi resolution non-local means filter for three dimensional magnetic resonance image denosing”, Image Processing , vol.6, no. 5, pp.558-568, 2011.

[6] Y.Y.Zhou, Ye.Z.F. and Huang.J.J, “Improved decision based detail preserving Variational method for removal of random valued impulse noise”, Image Processing , vol.6, Issue 7, pp.976-985, 2012.

[7] C.W.Luo,“Image Restoration and Decomposition using non convex non-smooth regularization and negative Hilbert-Sobolev norm”, Image Processing , vol.6, Issue 6, pp.706-716, 2011.

[8] S.Gai and L.Luo “Image denoising using normal inverse gaussian model in quaternion wavelet domain”, Springer Science, vol.74, pp.1107-1124, 2013.

[9] A.Boyat and B.K.Joshi, “Image Denoising using Wavelet Transform and Median Filtering”, international conference of IEEE, pp.1-6, 2013.

[10] M.Z.Alam, R.S.Mishra and AS Zadgaonkar, “Image denoising using common vector elimination vector by PCA and Wavelet Transform”, International Journal on Emerging Technologies, vol.6, pp.157-164 ,2015.

[11] J.Chai, H.Ji, Z.Shen and G.Ye, “Data-driven tight frame construction and image denoising”, Applied and Computational Harmonic Analysis, vol.22, pp.211-216, 2013.

[12] H.Talebi and P.Milanfar, “ Global image denoising”, IEEE Trasac. on Image Processing, vol.23, no.2, pp.755-768, 2014.

[13] S.Gu, L.Zhang, W.Zuo and X.Feng, “ Weighted nuclear norm minimization to image denoising”, IEEE conference on Computer Vision and Pattern Recognition, pp.2862-2869, 2014.

[14] H.C.Burger, C.J.Schuler and S.Harmeling, “ Image denoising: Can plain neural networks complete with BM3D?”, IEEE, pp.4321-4328, 2014.

[15] A.K.Bhandari, A.kumar, G.K.Singh and V.Soni, “Performance study of evolutionary algorithm for different wavelet filters for satellite image denoising using sub-band adaptive threshold”, Journal of Experimental & Theoretical Artificial Intelligence, 2015.