WAVELET BASED ENHANCED IMAGE DENOISING USING SELF-ORGANIZED MAPPING

[1]Amandeep Khalsa, [2]Aayushi Chadha
[1]Research Scholar, [2]Assistant Professor
Universal Group of Institutes Lalru, Punjab, India

Abstract: Images are usually corrupted by noise. Noise is an unwanted signal that affects 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, a new method including Self Organized Mapping (SOM) with Wavelet transform has been proposed. 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. It has also been shown that the proposed method has performed better in terms of Peak Signal to Noise Ratio (PSNR), which is reflected in the results.

Keywords: KNN, SOM, PSNR

I. INTRODUCTION

A digital image is two dimensional representation of a image. The digital image has a finite set of values. These finite set of digital values are referred as pixels. Pixels of the image represent grey levels, colors, heights etc. Basically the digital image is mathematical representation of the function f(x,y). Images are often represented by the rectangle.

Digital image processing does manipulation of the images through digital computer. So digital image processing performs processing on the images for the required task. Image processing performs various algorithms on the input image and the processed image is the output image.
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 the 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 main step in image processing is the step of removing various kinds of noise from the image. Sources of noise in an image mostly occur during storage, transmission and acquisition of the image. When the undesirable signal termed as noise, then the original image will degrade which reduces the quality of image. In the past decades, many researchers proposed various algorithms.

Images are usually corrupted by noise. Noise is nothing but an unwanted signal that affects the image. This noise or the unwanted signal degrades the quality of the image. Generally noise affects 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. The amount of preservation of this important or usual information should be as much as possible. There are two main forms in which noise can be present: - Additive form and Multiplicative form. So these models can be stated as:-

A. Additive Noise Model

If the nature of the noise is additive and it is present in the original image, it will produce a corrupted noisy image. Additive Noise Model will satisfy the following equation:-

$$w(x, y) = s(x, y) + n(x, y) \qquad (1)$$

here, s(x, y) is the original image intensity and n(x, y) indicates the added noise to produce the corrupted signal w(x, y) at (x, y) pixel location.

B. Multiplicative Noise Model

An important property of this model is that the noisy signal gets multiplied to the original signal.
It will obey the following rule:-

$$w(x, y) = s(x, y) + n(x, y) \quad (2)$$

here, s(x, y) is the original image intensity and n(x, y) indicates the added noise to produce the corrupted signal w(x, y) at (x, y) pixel location.
The main limitations of image accuracy are:-

- Blurness

- Noise

Roughly noise can be represented as:-

$$v(i) = u(i) + n(i) \qquad\qquad (3)$$

where i ∈I, v(i) is the observed value at pixel position i,n(i) is additional noise present in the image.

II. RELATED WORK

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 special characteristics of over-locality. Due to this over locality characteristic, many crucial discontinuities cannot 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 variation 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 variation 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.

Zhou *et.al.*[6] discussed many noise models according to the form of images. Mostly the images can be of the form real, satellite, medical images etc. The decomposition process is presented in form of new model. In the new proposed algorithm a non-convex, non-smooth regularization and also Hilter Sobolev spaces whose degree is negative in differentiability are applied. This captures the oscillatory patterns. A pseudo   solution which is already proven exists for the proposed model. To solve the minimization problem, variable splitting and penalty schemes are used. This problem is solved by using different numerical algorithm. Many experiments are carried out for the de-noising, de-blurring and decomposition for the real and synthetic images.

Lu.C.W[7] discussed the main issue in digital image processing is to reduce the noise in the various images. With respect to the various experiments, assumptions, applications, limitations, various image de-noising algorithms have been proposed.

Gai and Luo[8] proposed that in image denoising using normal inverse gaussian model, a algorithm based on image de-noising . This algorithm was proposed to eliminate Gaussian white noise. This suggested algorithm is based on the design format of MAP.MAP is Maximum Posteriori Estimator. In the proposed algorithm, the design of MAP is combined with QWT(Quaternion Wavelet Transform) which utilizes the NIG(Normal Inverse Gaussian)'s probability density function. QWT is a technique of near shift invariant.QWT includes one magnitude values as well as three phase values. The main purpose of NIG's probability density function is that it models the heavy tailed QWT coefficients and it thus describes the intra scale dependency between the coefficients of QWT. Generally NIG is specified by four real-value parameters. The NIG's probability density function is applied on the basis of prior probability distribution to model the coefficients. This is done by utilizing the Bayesian estimation technique. Generally for the estimation of parameters of NIG's probability density function, a method which is quite fast

and simple as well is suggested. The estimation of parameters of NIG's PDF is done from the neighbouring QWT coefficients. The result of performed experiments shows that the proposed method outperforms the many other existing techniques of de-noising on the basis of PSNR calculation, the structural similarity, and edge preservation. The proposed method clearly shows that it can remove Gaussian white noise in an effective manner.

Boyat and Joshi[9] proposed that 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. Many algorithms have been used from the past years for de-noising purpose. But the improvement is compulsory in the de-noising algorithms. So this paper nominates a new image de-noising algorithm. This algorithm is based on the combined effect of wavelet transform along with the median filtering. This algorithm removes the most of the noisy parts of the image and thus maintains the quality of the image. But there is a limitation of level decomposition in wavelet domain. The level of wavelet decomposition is restricted to three. The PSNR (Peak signal to Noise Ratio) and RMSE(Root Mean Square Estimation) illustrate the performance of de-noising technique which is a improvement over the other existing de-noising techniques.

Alam et.al.[10] proposed a technique by using PCA(Principal Component Analysis) along with the wavelet transform. In the proposed technique, decomposition of the image takes place. At first, the noisy image is decomposed followed by the PCA. The image is decomposed into various types of blocks. After this process, the Eigen values are calculated. Also in the decomposition process, from the each block, a common vector is eliminated. The noise is referred as a Gaussian random variable. In the process of de-noising, the de-noised image processed one more time by using the algorithm discussed above. For this purpose iT uses the wavelet transform. This post processing results in further improvement of the solution when denoising process takes place. Also, the results of the experiments shows better performance in terms of PSNR when compared to another image de-noising methods in the wavelet transform.

III. METHODOLOGY

The K means clustering suffers from the issue of initialization sensitivity. Hence to overcome that, we can use Self Organized Maps (SOM). SOM is used to clusters the features from the images and it will be used as input to the Neural Network which clusters the features as in Mean, Median and Standard Deviation.SOMs provide a more robust learning. Hence there is another alternative if there is a need for a stable alternative to k-means.

The algorithm employed in our work is defined in steps below

1) Image "Img" are read from the database in a sequential manner.

2) The read image is converted to grayscale"ImgGray"

3) Gaussian Noise of variable mean and variance isadded to "ImgGray" using non-overlapping blocks of size 3X3 neighborhood to generate the noisy image "ImgNoisy"

4) 2D- Discrete Wavelet Transform of noisy image is performed for a fixed value of the number of levels for wavelet decomposition.

5) Image statistics mean, median and standard deviation of the wavelet coefficients at a given level is calculated and stored in a variable "Final" to be used later for the clustering process.

6) Steps 3 and 5 is repeated for different sizes of neighborhood of Gaussian noise addition such as5X5, 7X7 and 9X9.

7) Steps 1-6 is repeated for all the images present in the dataset to generate the training dataset for the clustering process.

8) The number of cluster centroids is fixed and SOM clustering algorithm is executed for the data stored in the variable "Final".

9) The resulting centroids obtained after SOM clustering is stored in a variable "Centroids".

10) The noisy test image is read and converted intogray scale to generate the test image "ImgTest".

11) 2D- Discrete Wavelet transform of ImgTestistaken for the same number of levels of Wavelet Decomposition used during the training phase.

12) In a similar manner image statistics such as mean, median and standard deviation of the noisy image is calculated for a particular level and stored in a variable "Test".

13) The centroid from the variable "Centroids" which is closest to the variable "Test" is found out using L2 distance norm.

14) This centroid is used to calculate the value of soft-threshold according to Eqn (1).

15) The wavelet coefficients are soft-thresholded using the value of soft-threshold calculated in step 14.

16) Finally the output image is reconstructed using the soft-thresholded wavelet coefficients, and its Power Spectrum Noise Ratio (PSNR) is calculated.

Haar Wavelet Transform

In the Fourier transform, two variable function of 2DHaar wavelet transform is

$$\exp(j(\omega_1 t_1 + \omega_2 t_2)) \qquad (22)$$

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

$$\emptyset_{j,m,n}(x,y) = 2^{j/2}\emptyset(2^j x - m, 2^j y - n) \qquad (23)$$

The wavelet function are defined as follows

$$\varphi_j^i(x,y) = 2^{j/2}\varphi^i(2^j x - m, 2^j y - n) \quad \text{i= \{H,V,D\}} \quad (24)$$

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.
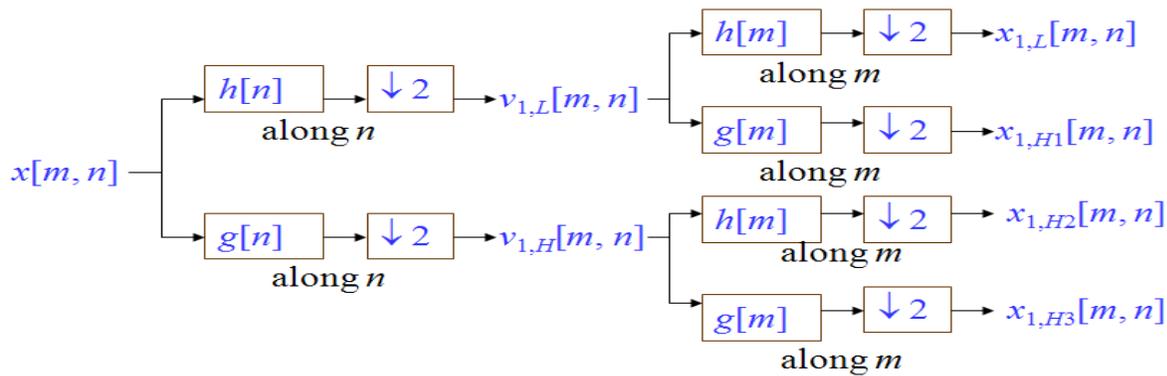
Fig.1: 2DHaarwavelet transform

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.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 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 Harrisoperator.
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

$$PSNR = 10 * \log_{10} \frac{Imax * Imax}{MSE}$$

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

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

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

VI. 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 with K means). The proposed DWT with SOM based clustering gives high PSNR valves than the existing methodsof noise removal. The proposed method is more suitable way of noise reduction
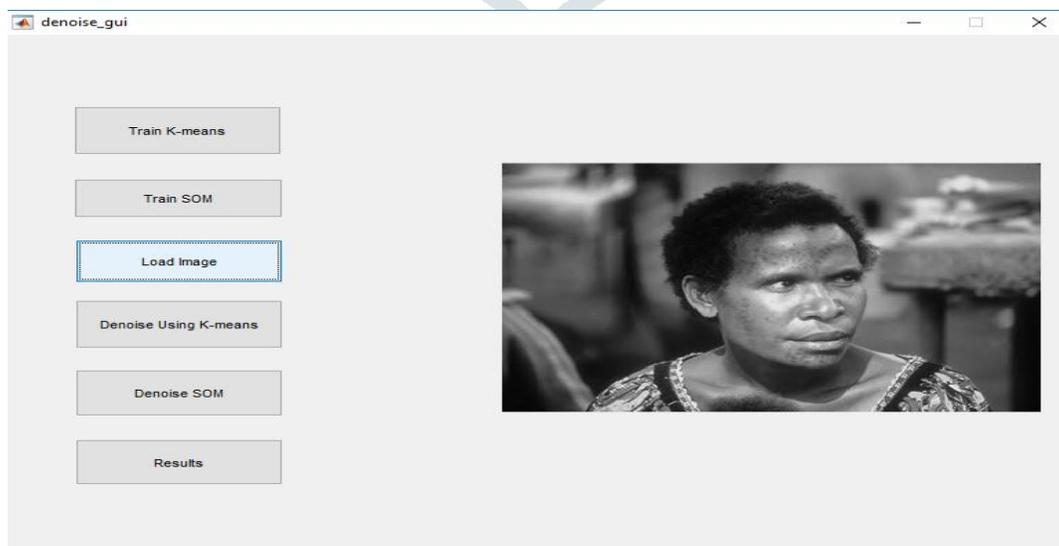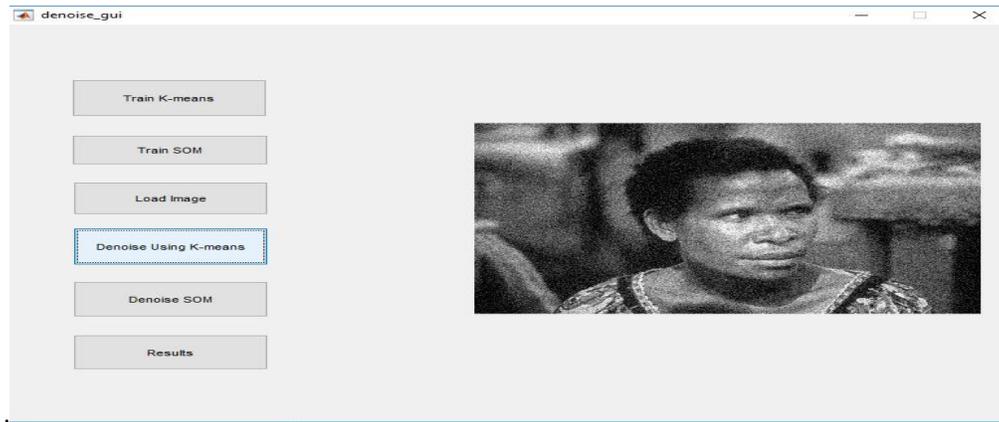

Fig. 2:

Fig.3:

Fig. 3:

Fig. 4:

Fig.5:

V. CONCLUSION

In the proposed work, an effort has been made to develop i m a g e denoising methods using SOM and wavelet transform. The performance of this method is evaluated and compared with that of current state-of-the-art. This work aims at developing a denoising method under this type of noise corruption. A Daubechies wavelet domain based 2 level approach with bayes shrinkage thresholding technique has been developed. The thresholding on wavelet coffecents determine by thresholding method developed in the base work. The algorithm is applied to several images and performance is evaluated using statistical indices like PSNR. Experimental results exhibits improvement over the existing stat-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 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 technique in sparse domain.
• Developing restoration technique in real-time embedded platform.

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