International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-05, Aug 2018

Image Restoration using DWT in a Tile based manner

J. Ghosh Dastidar, St. Xavier's College, Kolkata, India, j.ghoshdastidar@sxccal.edu

S. Dutta, St. Xavier's College, Kolkata, India, shawnidutta83@gmail.com

S. Bhattacharya, St. Xavier's College, Kolkata, India, sharmistha.bhattacharya96@gmail.com

A. Jaiswal, St. Xavier's College, Kolkata, India, anushkajaiswal08@gmail.com

Abstract **This paper proposes a Discrete Wavelet Transformation based algorithm to denoise and restore a degraded image. The algorithm exploits the fact that all portions of an image may not have undergone the same degree of degradation. Hence handling different portions of the image separately yields better results. The paper further compares the performance of the algorithm with the well-known Weiner filter.**

Keywords —Image Restoration, Discrete Wavelet Transformation, Weiner Filter, de-noising, tiling, noise

I. Introduction

An image consists of numerous facts and memories. Atmospheric turmoil degrades image quality, which gives rise to the concept of Image Restoration. Generally, degradation of an image occurs due to blur, noise, and motion. Image restoration is a methodology that recovers degradation that occurred at the time of taking the image [17]. Along with blurring, the image is often corrupted by noise while capturing and transmitting the image [9]. While capturing the images with a CCD (Charged Couples Device) camera, the major factors which introduce noise in the resulting image are light levels and server temperature. While transmitting an image, the interference in the transmission channel is another reason for an image being corrupted [16]. The main purpose of de-noising techniques is to remove random noise while preserving the original details of the image [15]. There are various sources of degradation which may be grouped into the following categories [3]:

1) Point degradation
2) Spatial degradation
3) Temporal degradation
4) Chromatic degradation
5) Degradations resulting out of the combinations of the above

All of these degradations can be reduced using Discrete Wavelet Transformation method. A Discrete Wavelet Transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. Wavelets, appropriately separates noisy signals from the image signal, so it provides a strong basis for image processing [14].

Image noise is an undesirable effect that obscures the desired information. 'Noise' can also be referred to as an unwanted signal in terms of signal processing. Different types of noises are as follows:

Gaussian Noise – In digital image, Gaussian noise can appear during acquisition. As for example sensor noise may be observed due to high temperature or poor illumination, etc. [13]. Gaussian noise can be reduced using a spatial filter. But application of this filter may give an undesirable result because they blur the fine-scaled edges and details due to its blockage capacity of high frequencies.

Salt-and-Pepper Noise – It is an impulsive noise. An image having salt-and-pepper noise will contain randomly occurring bright pixels in dark regions and dark pixels in bright regions. This type of noise occurs due to analog-to-digital converter errors, bit errors in transmission, etc. [12]. Such noise can be removed by applying median filters, interpolating around dark/bright pixels [6].

Periodic Noise – This type of noise occurs due to electromechanical or electrical interference while capturing an image [11]. An image having periodic noise will contain repetitive patterns superimposed on the image. In frequency domain it looks like discrete spikes. In frequency domain it can be reduced well using notch filters.

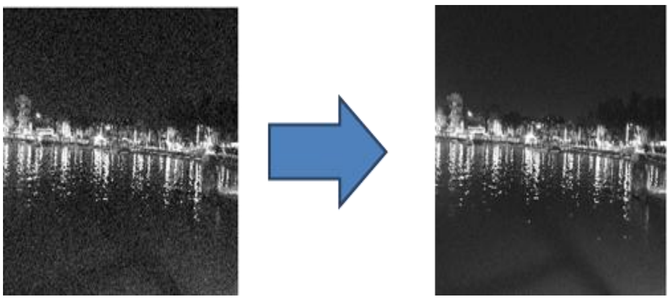


Fig.1. An image before and after restoration.

Our objective is to design an algorithm that will remove noise from an image. In order to do this, the given image is decomposed into 4 tiles and on each of these tiles noise removal techniques are applied. These techniques involve the use of Discrete Wavelet Transform (DWT). Normally

 DOI : 10.18231/2454-9150.2018.0647

the use of DWT for de-noising an image implies fitting the whole image into each sub band generated by the DWT and then filtering each of the sub-bands. However, in the proposed technique in the image is decomposed into 4 tiles and noise is eliminated from each of them separately. This technique has proved to be more effective because localized parameters may be set for different regions of an image depending upon the level of degradation each region has undergone. Considering the image as a whole, would compel the de-noising method to use the same parameters for all regions. This at times leads to un-necessary blurring at portions of the image where the degree of degradation is low compared to other regions. After removing noise from each of the tiles separately, they are rejoined to get the de-noised image.

II. Literature Review

The objective of image restoration is to estimate $f(x, y)$ from the observed image $g(x, y)$ using the known value of an operator, H [1]. The overall degradation and restoration model is shown in Fig. 2. The operator, H may be linear or nonlinear.

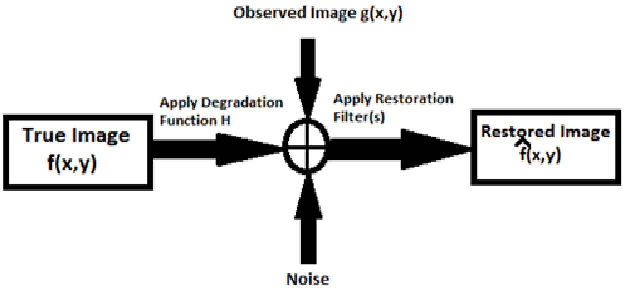


Fig. 2. Image restoration model [8]

A. Image restoration by IBD (Iterative Blind De-convolution)

Iterative Blind De-convolution (IBD) is an approach brought up by Ayers and Dainty. It is the technique of sharpening a blurred image when the point spread function is not known. In fact, the true image is also not present. So the restoration process is very difficult in this case. It is based on the principle of Fourier Transformation. The Iterative Blind De-convolution algorithm has a fine anti-noise capability giving better quality output and also has a higher level of resolution. The disadvantage of this method is that the initial image can have an effect on the final output produced and also the convergence of the iterative method cannot be assured [10].

B. Image Restoration by NAS-RIF (Nonnegative and Support Constraints Recursive Inverse Filtering)

The basic purpose of the Nonnegative and Support Constraints Recursive Inverse Filtering algorithm is to obtain an estimate of the final image from a blurred or distorted image. The idea of this method was proposed by D. Kundur in which the estimated target image could be found by minimizing an error function using the nonnegative pixel values of the image along with its domain. This error function can then be globally optimized which theoretically would be equivalent to the real image. The benefits of this algorithm is that we do not need any prior knowledge of the initial degraded image or any other information such as the parameters of the Point Spread Function. Hence this algorithm converges to a global least. We only have to make sure that the estimated image is not negative and also determine the support domain of the target area. The only drawback of this technique is that it is useful only for symmetric backgrounds and hence is sensitive to noise [10].

C. Image Restoration by LPA-ICI algorithm

The LPA-ICI algorithm is a method in which the intensity of illumination varies depending on the depth and reflectivity of features in the image. It is a nonlinear method useful with respect to blurring or smoothening operations or the irregularities performed on an image. The effectiveness, efficiency and performance level of this method can be observed by simulation experiments [10].

D. Image Restoration by Richardson-Lucy De convolution Algorithm

The Richardson Lucy de-convolution algorithm is an iterative procedure for recovering a latent image that has been blurred or degraded by a known point spread function. So this algorithm is dependent on the type of noise or the nature of the distortion phenomenon. Basically in this method restoration is performed with respect to the degradation measure or the given noise function [9].This algorithm requires more number of iterations to converge with respect to linear methods. Hence it is very slow.

III. Detailed Design

The proposed system works by partitioning the image into four quadrants called tiles. Each of these tiles are then individually processed so as to restore them as best as is possible. Partitioning the image into tiles and then processing each individually allows one to apply different restoration techniques to the tiles depending upon the degree of damage that may have been caused to the tiles. The process of partitioning has been shown in Fig. 3.

Post partitioning, an attempt is made to eliminate noise from each of the tiles using a wavelet based method. Each of the resultant de-noised tiles are then rejoined for the purpose of getting the entire de-noised image.

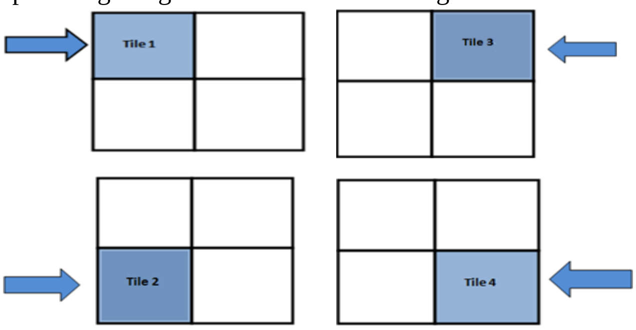


Fig. 3. Partitioning of an image into tiles

 DOI : 10.18231/2454-9150.2018.0647

ISSN : 2454-9150 Vol-04, Issue-05, Aug 2018

A. *The Wavelet Transform*

Wavelets are signals having an irregular shape and are local in time and scale. A wavelet is a limited duration wave form which has an average value of 0. Sinusoids theoretically extend from minus infinity to plus infinity, whereas wavelets differ from sinusoids for having a beginning and an ending. Wavelets integrate to 0 and they wave up and down across the axis. A signal can be decomposed into component wavelets using the wavelet transform. After that, to remove some of the details the coefficients of the wavelet may be decimated. Wavelets possess a great advantage for being capable to separate fine details in a signal while very large wavelets can identify coarse details. The main advantage of using wavelets is that they offer a simultaneous localization in time and frequency domain. In fact it has the ability to compress or de-noise a signal without degradation. The Discrete Wavelet Transform (DWT) is based on time-scale representation [18]. It decomposes signals into multi-resolution sub bands. The 2-D DWT and 2- D Inverse DWT (IDWT) play an essential role in image processing fields [4]. We will exploit this property of wavelets in order to de-noise a degraded image. It offers high robustness to common signal processing [2].

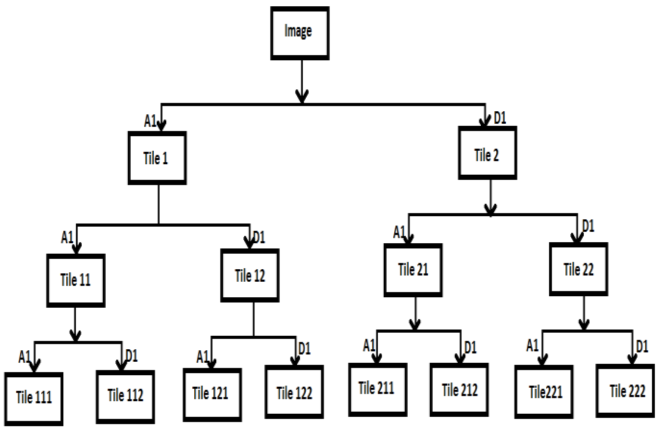
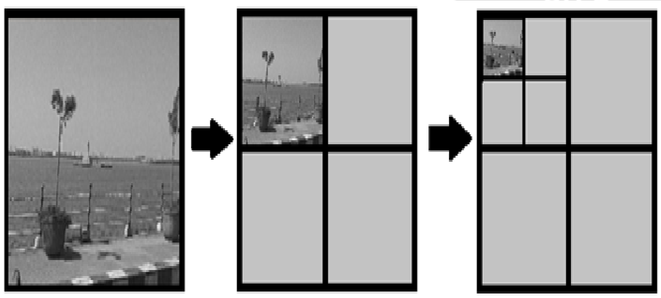


Fig. 4. DWT Decomposition



(a) (b) (c)

Fig. 5. DWT Decomposition of image (a)Input image (b) after one level 2D-DWT Decomposition (c) after two level 2D-DWT Decomposition

The DWT decomposes the input image high pass components and low pass components using High Pass Filter (HPF) and Low Pass Filter (LPF) and produces the first level of hierarchy. This process is iterated to obtain multiple hierarchies as shown in Fig. 4. A1 and D1 are respectively the approximation and detail filters.

The input image is first decomposed into four sub bands of LL, LH, HL and HH. Further the LL sub band that is the top left sub band is decomposed into four more sub bands as we can see in Fig. 5. An image of size N X N hence is decomposed to four N/2 X N/2 sub bands. To each of the four tiles, the following noise removal algorithm is applied.

B. *Noise Removal Algorithm*

Step 1: The image is transformed into 2-D signal and the signal is decomposed upto a selected level (say N) using the technique shown in Fig. 4.. This step returns two vectors – a vector C and a vector L. The vector (C) is organized as A(N), H(N), V(N), D(N), H(N-1), V(N-1), D(N-1), ..., H(1), V(1), D(1), where A (contains the approximation coefficients), H (contains the horizontal detail coefficients), V (contains the vertical detail coefficients), and D (contains the diagonal detail coefficients. The vector (L) determines the length of each component.

Step 2: The coefficients of an N-level decomposition of the signal are all the components of N level approximation and first N levels of detail coefficients.

Step 3: Choosing threshold is an important criteria as very small threshold includes more coefficients which causes less smoothed quality whereas, large threshold results in over-smoothing due to elimination of more coefficients.

There exists many thresholding methods and these methods can be broadly classified into two categories- global thresholding and level-dependent thresholding. In global thresholding, a single value of is chosen and it is applied globally to all real wavelet coefficients. In case of level-dependent thresholding different threshold values for each wavelet level j are chosen.

Step 4: In this step a multilevel wavelet reconstruction of the image matrix is done based on the wavelet decomposition structure is performed.

The restored tiles are then re-joined to form the entire image.

IV. Results and Discussion

The algorithm has been implemented using MATLAB and has been tested using a varied collection of images. Some

 DOI : 10.18231/2454-9150.2018.0647

of these images were infused with deliberate noises such as Gaussian noise and salt-and-pepper noise [7]. The effect of the noise removal algorithm proposed here was measured by calculating the Signal to Noise Ratio (SNR) and the Peak Signal to Noise Ratio (PSNR). An attempt was then made to apply other standard noise removal techniques such as the Weiner filter on the same set of noise infused images [5]. In almost all cases the results obtained using the proposed algorithm proved to be superior to Weiner filter.

The noisy image shown in Fig. 1. has been subjected to the proposed algorithm. The effect of the application of the algorithm on each of the four tiles of the image has been shown in Fig. 6, Fig. 7, Fig. 8 and Fig. 9.

(a)

(b)

Fig 6. (a) Tile 1 of degraded image(Gaussian Noise) (b) Tile 1 of the image de-noised by DWT

(a)

(b)

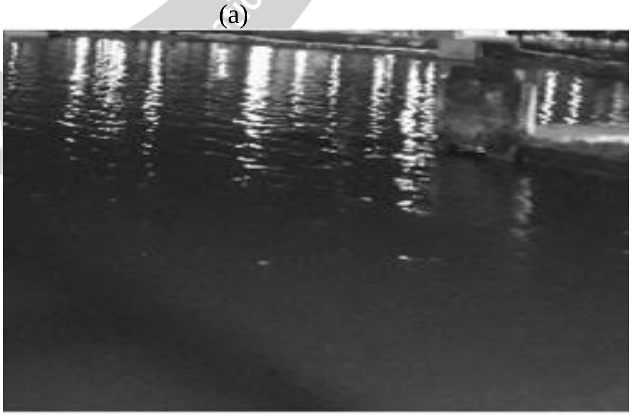
Fig 7. (a) Tile 2 of degraded image(Gaussian Noise) (b) Tile 2 of the image de-noised by DWT

(a)

(b)

Fig 8. (a) Tile 3 of degraded image(Gaussian Noise) (b) Tile 3 of the image de-noised by DWT

(a)



(b)

Fig 9. (a) Tile 4 of degraded image(Gaussian Noise) (b) Tile 4 of the image de-noised by DWT

The data in Table 1 shows the SNR values of each of the four tiles of the image (with noise) and the de-noised image. It clearly shows that the SNR values have increased in each de-noised tiles with respect to the tiles degraded by Gaussian noise.

 DOI : 10.18231/2454-9150.2018.0647

Table 1. SNR for the image-tiles in Fig. 6-9.

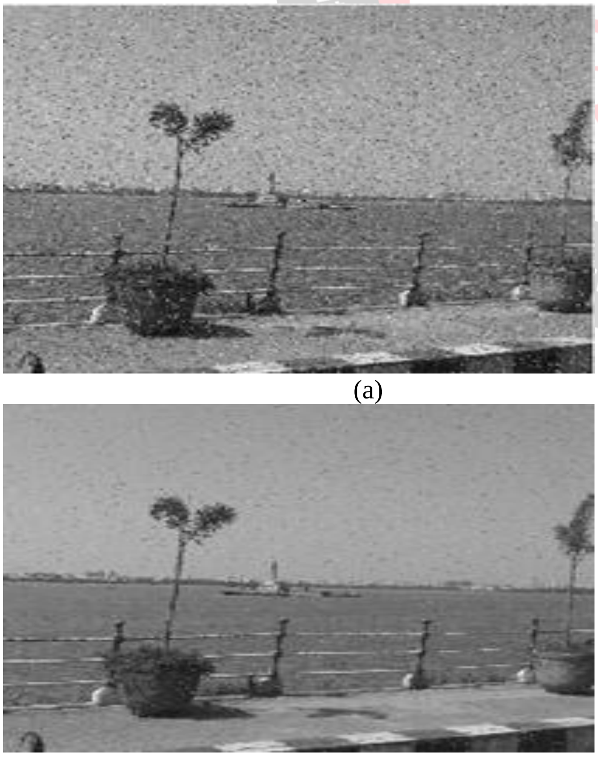
Type of image	Tile numbers	SNR (in dB)
Original degraded image	**Tile1**	13.6882
	Tile2	14.8751
	Tile3	15.2244
	Tile4	15.2031
De-noised using DWT	**Tile1**	14.1184
	Tile2	15.8262
	Tile3	15.837
	Tile4	16.1506

Table 2 shows the SNR and the PSNR values of the noisy image, de-noised image using the Weiner filter and the de-noised image using the proposed algorithm.

Table 2. SNR and PSNR values for Fig. 1.

Type of image	SNR (in dB)	PSNR (in dB)
Original degraded image	14.6307	--
De-noised using wiener	15.0873	19.0608
De-noised after tiling using DWT	20.9105	23.9349

As we can see the SNR values slightly increased from the original degraded image in the image which is de-noised using wiener filter. But it has rapidly increased in the proposed approach. The PSNR value in the image de-noised using Wiener filter is also less than the PSNR value of the image de-noised using the proposed approach.



(a) (b)

(c)

Fig. 10. (a) Original degraded image (Salt and pepper Noise) (b) Image de-noised by Wiener filter (c) Image de-noised by DWT

Fig.10. Shows an image that has been degraded using salt and pepper noise and the effect on the same of the Weiner filter and the proposed DWT based method. Table 3 shows the values of SNR and PSNR calculated for the three images shown in Fig. 10. The values show that the proposed method is also successful against salt and pepper noise. Tables 2 and 3 also proves the superiority of the proposed method. The same is also obvious visually in Fig. 10 and numerically from Table 3.

The quality of the noisy image restored using the proposed technique is better than that obtained by applying the Weiner filter. The SNR for Weiner is 16.2881 whereas for DWT is 20.8311. The PSNR value for the proposed method (23.3211) is also superior to Weiner (20.7379). Table 2 gives a similar outcome for Fig. 1.

Table 3. SNR and PSNR values for Fig. 10.

Type of image	SNR(in dB)	PSNR(in dB)
Original degraded image (salt-and-pepper noise)	15.6331	--
De-noised using wiener	16.2881	20.7379
De-noised after tiling using DWT	20.8311	23.3211

Fig. 11 shows graphically the superiority of the SNR values of the restored images (Fig. 1 and Fig. 10) using the proposed method over the ones obtained by using the Weiner filter.

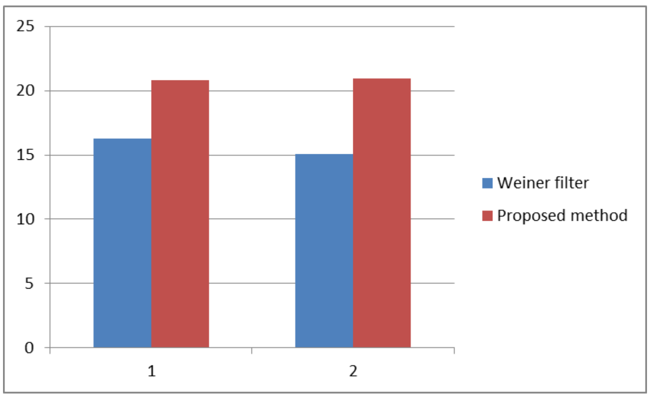


Fig. 11 Comparison of SNR values for Fig. 1 and Fig. 10.

 DOI : 10.18231/2454-9150.2018.0647

Fig. 12 shows graphically the superiority of the PSNR values of the restored images (Fig. 1 and Fig. 10) using the proposed method over the ones obtained by using the Weiner filter.

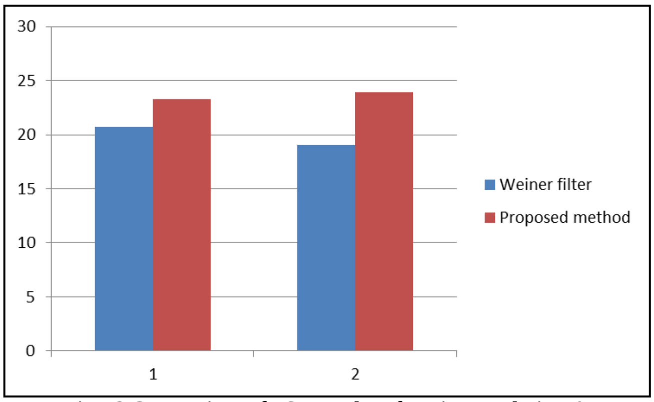


Fig. 12 Comparison of PSNR values for Fig. 1 and Fig. 10.

The bar charts shown in Fig. 11 and Fig. 12 convincingly prove the success of the proposed method over conventional filters such as the Weiner.

V. Conclusion

In this paper an attempt has been made to give an idea of image restoration using wavelet based techniques. In the proposed approach the image has been decomposed into tiles. As seen from the results, applying the denoising technique on each of the tiles individually gives a better result. This is because different portions of an image may have undergone different proportions of degradation. A close examination of the first section of Table 1 reflects the same. The signal-to-noise ratio varies across the four tiles. Thus, applying the same process uniformly to the entire image gives limited success. A comparative study between the proposed method and the Wiener filter has been made. As observed the disadvantage of Wiener filter is that it requires a prior power spectral density of the real image which in practical cases is not available. But in the DWT-based approach, it gives a better performance as it is dependent on spectral components of the image [3]. It is also observed that the proposed method gives a better result in terms of PSNR and SNR values. However, a major drawback of the proposed technique is that it is very time consuming. The efficacy of the technique may be improved by increasing the depth of the tiling process. However, an increase in number of tiles it will make the process more resource intensive. Thus, a balance would have to be struck between the depth and the time complexity.

References

[1] Siddaraju K, Gururaju, “Digital Image Restoration”, International Journal of Scientific & Engineering Research, Volume 6, Issue 4 April 2015, 1270, ISSN 2229–5518.

[2] Dolley Shukla, Jyoti Sahu, “Wavelets: Basic Concepts”, Volume 2, Issue 4 October 2013, ISSN 2319–2518.

[3] Archee Naz, Anjan Talukdar, Kandarpa Kumar Sarma, “Digital Image Restoration Using Discrete Wavelet Transform Based Approach”, IRNet Transactions on Electrical and Electronics Engineering (ITEEE), Volume 1, Issue 2012, ISSN 2319–2577.

[4] Prabhjot Kour, “Image Processing Using Discrete Wavelet Transform”, IPASJ International Journal of Electronics & Communication (IIJEC) ,Volume 3, Issue 1 January 2015, ISSN 2321–5984.

[5] Ishfaq Nazir, Roohi Jan, Uzma Nazir, Adil Yousuf, “A Comparative Review Paper for Noise Models and Image Restoration Techniques”, International Journal of Computer Science and Mobile Computing, pp. 405–410, Volume 6, Issue 6 June 2017, ISSN 2320–088X.

[6] Angel Ida Chellam.J, Saranya. N, Mohan Kumar B, “Denoising Image using Differential Geometry Algorithm”, IJIACS, Volume 6, Issue 7 July 2017, ISSN 2347–8616.

[7] Reka Durai, Dr.V.Thiagarasu, “A Study and Analysis on Image Processing Techniques for Historical Document Preservation”, International Journal of Innovative Research in Computer and Communication Engineering (An ISO 3297: 2007 Certified Organization), Volume 2, Issue 7 July 2014, ISSN (Online) 2320–9801, ISSN (Print) 2320–9798.

[8] Sujita Pillai , Sanjay Khadagade, “A Review on Digital Image Restoration Process”, International Journal of Computer Applications ,Volume 158, No. 7 January 2017, ISSN 0975–8887.

[9] Er. Amit Kumar Saini, Er. Maninder Kaur, “Restoration of Motion Blurred Image Using Spatial Domain”, International Journal of Latest Trends in Engineering and Technology (IJLTET), Volume 5, Issue 4 July 2015, ISSN 2278–621X.

[10] Shilpa Rani, Sonika Jindal, Bhavneet Kaur, “A Brief Review On Image Restoration Techniques”, International Journal of Computer Applications, Volume 150, No. 12 September 2016, ISSN 0975–8887.

[11] Prabhishek Singh, Raj Shree, “A Comparative Study to Noise Models and Image Restoration Techniques”, International Journal of Computer Applications, Volume 149, No. 1 September 2016, ISSN 0975–8887

[12] Shivani Sharma, Er. Kamal Kumar, “A Comparison of Salt and Pepper Noise Removal Filters”, International Journal of Engineering Science and Computing, 2627, Volume 6, Issue No. 8 August 2016.

[13] Mohd Awais Farooque, Jayant S.Rohankar, “Survey On Various Noises And Techniques For Denoising The Color Image”, International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 2, Issue 11 November 2013, ISSN 2319–4847.

[14] Alka Vishwa, Vishakha Goyal, “An Improved Threshold Estimation Technique for Ultrasound Image Denoising”, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 7 July 2013, ISSN 2277–128X.

[15] Barjinder Kaur, Manshi Shukla, “Image De-noising and its Methods: A Survey”, IJCSMC, pp. 234–238, Volume 3, Issue 6 June 2014, ISSN 2320–088X.

[16] Sukhjinder Kaur , “ Noise Types and Various Removal Techniques” , International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Volume 4, Issue 2 February 2015, ISSN 2278–909X.

[17] Monika Maru, M. C. Parikh, “Image Restoration Techniques: A Survey”, International Journal of Computer Applications, Volume 160, No. 6 February 2017, ISSN 0975–8887.

[18] Suchitra Oinam, Hemanth Kumar P., S. Basavaraj Patil, “Compression Of Time Series Signal Using Wavelet Decomposition, Wavelet Packet And Decimated Discrete Wavelet Compression Transforms Techniques And Their Comparison”, International Journal of Advanced Research in Computer and Communication Engineering, Volume 2, Issue 3 March 2013, ISSN (Print) 2319–5940 , ISSN (Online) 2278–1021.

 DOI : 10.18231/2454-9150.2018.0647