INTERNATIONAL JOURNAL OF SCIENTIFIC PROGRESS AND RESEARCH (IJSPR) ISSN: 2349-4689
Issue 105, Volume 36, Number 03, 2017

A Literature Review on Image Denoising by using SURE-LET and Wavelet Transform

Deepak Bharti[1], Prof. Akhilesh Bansiya[2], Prof. Raj Kumar Paul[3]

[1]Mtech Scholar, [2]Guide, [3]HOD

Department of Computer Science and Engineering, VIT, RKDF University, Bhopal

Abstract- Image Denoising is an essential pre-handling errand before additionally preparing of image like segmentation, feature extraction, texture analysis and so on. The motivation behind denoising is to expel the noise while holding the edges and other nitty gritty features as much as could be expected under the circumstances. This noise gets presented amid procurement, transmission and gathering what's more, stockpiling and recovery forms. Accordingly, there is debasement in visual nature of an image. The noises considered in this proposition Additive Gaussian White Noise (AWGN), Additive Gaussian White Noise (Speckle) Noise. Among the at present accessible medicinal imaging modalities, ultrasound imaging is thought to be non invasive, for all intents and purposes safe to the human body, versatile, precise, and practical. Tragically, the nature of restorative ultrasound is for the most part restricted because of Speckle noise, which is an inborn property of medicinal ultrasound imaging, and it for the most part tends to decrease the image determination and complexity, consequently lessening the analytic estimation of this imaging methodology. Therefore, dot noise diminishment is a vital essential, at whatever point ultrasound imaging is utilized for tissue portrayal.

Keywords- Image Denoising , SURE-LET , PSNR , MSE.

I. INTRODUCTION

Digital Image Processing usually refers to the processing of a 2-dimensional (2-D) picture signal by a digital hardware. The 2-D image signal might be a photographic image, text image, graphic image (including synthetic image), biomedical image (X-ray, ultrasound, etc.), satellite image, etc. In a broader context, it implies processing of any 2-D signal using a dedicated hardware, e.g. an application specific integrated circuit (ASIC) or using a general-purpose computer implementing some algorithms developed for the purpose.

An image is a 2-D function (signal), f (x, y), where x and y are the spatial (plane) coordinates. The magnitude of f at any pair of coordinates (x,y) is the intensity or gray level of the image at that point. In a digital image, x,y, and the magnitude of f are all finite and discrete quantities. Each element of this matrix (2-D array) is called a picture element or pixel. Image processing refers to some algorithms for processing a 2-D image signal, i.e. to operate on the pixels directly (spatial- domain processing) or indirectly (transform-domain processing). Such a processing may yield another image or some attributes of the input image at the output.

It is a hard task to distinguish between the domains of image processing and any other related areas such as computer vision. Though, essentially not correct, image processing may be defined as a process where both input and output are images. At the high level of processing and after some preliminary processing, it is very common to perform some analysis, judgment or decision making or perform some mechanical operation (robot motion). These areas are the domains of artificial intelligence (AI), computer vision, robotics, etc.

Digital image processing has a broad spectrum of applications, such as digital television, photo-phone, remote sensing, image transmission, and storage for business applications, medical processing, radar, sonar, and acoustic image processing, robotics, and computer aided manufacturing (CAM) and automated quality control in industries. Fig. 1.1 depicts a typical image processing system.

Fig.1.1 A typical digital image processing system

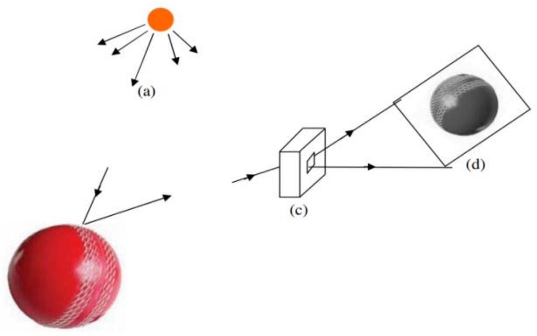

Fig. 1.2 An example of image acquisition process (a) illumination energy source, (b) an object, (c) imaging system (d) 2-Dplanar image

Image processing may be performed in the spatial-domain or in a transform- domain. To perform a meaningful and useful task, a suitable transform, e.g. discrete Fourier transform (DFT), discrete cosine transform (DCT), discrete Hartley transform (DHT) , discrete wavelet transform (DWT), etc., may be employed. Depending on the application, a suitable transform is used.

Image enhancement techniques are used to highlight certain features of interest in an image. Two important examples of image enhancement are: (i) increasing the contrast, and (ii) changing the brightness level of an image so that the image looks better. It is a subjective area of image processing. On the other hand, image restoration is very much objective. The restoration techniques are based on mathematical and statistical models of image degradation. Denoising (filtering) and deblurring tasks come under this category.

Image processing is characterized by specific solutions; hence a technique that works well in one area may totally be inadequate in another. The actual solution to a specific problem still requires a significant research and development.

Image restoration is one of the prime areas of image processing and its objective is to recover the images from degraded observations. The techniques involved in image restoration are oriented towards modeling the degradations and then applying an inverse procedure to obtain an approximation of the original image. Hence, it may be treated as a deconvolution operation.

Depending on applications, there are various types of imaging systems. X-ray, Gamma ray, ultraviolet, and ultrasonic imaging systems are used in biomedical instrumentation. In astronomy, the ultraviolet, infrared and radio imaging systems are used. Sonic imaging is performed for geological exploration. Microwave imaging is employed for radar applications. But, the most commonly known imaging systems are visible light imaging. Such systems are employed for applications like remote sensing, microscopy, measurements, consumer electronics, entertainment electronics, etc.

The images acquired by optical, electro-optical or electronic means are likely to be degraded by the sensing

Environment. The degradation may be in the form of sensor noise, blur due to camera misfocusing, relative object camera motion, random Atmospheric turbulence, and so on. The noise in an image may be due to a noisy channel if the image is transmitted through a medium. It may also be due to electronic noise associated with a storage-retrieval system.

Noise in an image is a very common problem. An image gets corrupted with different types of noise during the processes of acquisition, transmission/ reception, and storage/ retrieval. Noise may be classified as substitutive noise (impulsive noise: e.g., salt & pepper noise, random-valued impulse noise, etc.) and additive noise (e.g., additive white Gaussian noise). The impulse noise of low and moderate noise densities can be removed easily by simple denoising schemes available in the literature. The simple median filter works very nicely for suppressing impulse noise of low density. However, now-a-days, many denoising schemes are proposed which are efficient in suppressing impulse noise of moderate and high noise densities. In many occasions, noise in digital images is found to be additive in nature with uniform power in the whole bandwidth and with Gaussian probability distribution. Such a noise is referred to as Additive White Gaussian Noise (AWGN). It is difficult to suppress AWGN since it corrupts almost all pixels in an image. The arithmetic mean filter, commonly known as Mean filter, can be employed to suppress AWGN but it introduces a blurring effect.

Efficient suppression of noise in an image is a very important issue. Denoising finds extensive applications in many fields of image processing. Image denoising is usually required to be performed before display or further processing like texture analysis, object recognition, image segmentation, etc. Conventional techniques of image denoising using linear and nonlinear techniques have already been reported and sufficient literature is available in this area.

Recently, various nonlinear and adaptive filters have been suggested for the purpose. The objectives of these schemes are to reduce noise as well as to retain the edges and fine details of the original image in the restored image as much as possible. However, both the objectives conflict each other and the reported schemes are not able to perform satisfactorily in both aspects. Hence, still various research workers are actively engaged in developing better filtering schemes using latest signal processing techniques. In this doctoral research work, efforts have been made in developing some novel filters to suppress AWGN quite efficiently.

A. Noise in Digital Images

Various types of noise corrupting an image signal are studied; the sources of noise are discussed, and mathematical models for the different types of noise are presented.

B. Sources of Noise

During acquisition, transmission, storage and retrieval processes an image signal gets contaminated with noise. Acquisition noise is usually additive white Gaussian noise (AWGN) with very low variance. In many engineering applications, the acquisition noise is quite negligible. It is mainly due to very high quality sensors. In some applications like remote sensing, biomedical instrumentation, etc., the acquisition noise may be high enough. But in such a system, it is basically due to the fact that the image acquisition system itself comprises of a transmission channel. So if such noise problems are considered as transmission noise, then it may be concluded that acquisition noise is negligible. The acquisition noise is considered negligible due to another fact that the human visual system (HVS) can't recognize a large dynamic range of image. That is why; an image is usually quantized at 256 levels. Thus, each pixel is represented by 8 bits (1 byte). The present-day technology offers very high quality sensors that don't have noise level greater than half of the resolution of the Analog-to-digital converter (ADC).

II. SYSTEM MODEL

Among the many methods that have been proposed to perform this task, there exists a class of approaches that use a multiplicative model of speckled image formation and take advantage of the logarithmical transformation in order to convert multiplicative speckle noise into additive noise. The common assumption made in a dominant number of such studies is that the samples of the additive noise are mutually uncorrelated and obey a Gaussian distribution. Now the noise became AWGN.

Many spatial-Domain filters such as Mean filter, Median filter, Alpha-trimmed mean filter, Wiener filter, Anisotropic diffusion filter, Total variation filter, Lee filter, Non-local means filter, Bilateral filter etc. are in literature for suppression of AWGN. Also many Wavelet-domain filters such as VisuShrink, SureShrink, BayesShrink, Locally adaptive window maximum likelihood estimation etc. are proposed to suppress the AWGN effectively. The recently developed Circular Spatial Filter (CSF) also performed efficiently under high variance of noise . Performance of these filters are compared with the existing filters in terms of peak-signal-to-noise-ratio (PSNR), universal quality index (UQI) and execution time (ET). The Mean filter Gaussian noise under low noise conditions efficiently. On the other hand CSF performs well under moderate and high noise conditions. It is also capable of retaining the edges and intricate details of the image. In this filter, filtering window is combination of distance kernel and gray level kernel. we can also make adaptive the window size of CSF depends on noise variance. where the size of the window varies with the level of complexity of a particular region in an image and the noise power as well. A smooth or flat region (also called as homogenous region) is said to be less complex as compared to an edge region. The region containing edges and textures are treated as highly complex regions. The window size is increased for a smoother region and also for an image with high noise power.

From the wavelets properties and behavior, they play a major role in image compression and image denoising. Wavelet coefficients calculated by a wavelet transform represent change in the time series at a particular resolution. By considering the time series at various resolutions, it is then possible to filter out the noise. The wavelet equation produces different types of wavelet families like Daubechies, Haar, symlets, coiflets, etc. .Wavelet Thresholding is the another important area in wavelet domain filtering. Wavelet filters, Visu Shrink, Sure Shrink, Bayes Shrink, Neigh Shrink, Oracle Shrink, Smooth Shrink are the some of filtering techniques to remove the noise from noisy images. We can apply fuzzy techniques to wavelet domain filters to the complexity.

A. Fundamentals of Digital Image Processing

An image may be described as a two-dimensional function I.

$$I = f(x,y)$$

Where x and *y* are spatial coordinates. Amplitude of *f* at any pair of coordinates *(x, y)* is called intensity *I* or gray value of the image. When spatial coordinates and amplitude values are all finite, discrete quantities, the image is called digital image.

Digital image processing may be classified into various sub branches based on methods whose:

Inputs and outputs are images and inputs may be images where as outputs are attributes extracted from those images.

Following is the list of different image processing functions based on the above two classes.

(i) Image Acquisition

(ii) Image Enhancement

(iii) Image Restoration

(iv) Transform-domain Processing

(v) Image Compression

(vi) Morphological Image Processing

(vii) Image segmentation

(viii) Color Image Processing

(ix) Image Representation and Description

(x) Object Recognition

For the first seven images processing functions the inputs and outputs are images where as for the last three the outputs are attributes from the input images. Above all functions, With the exception of image acquisition and display are implemented in software. Image processing may be performed in the spatial-domain or in a transform-domain. Depending on the application, a efficient transform, e.g. discrete Fourier transform (DFT) , discrete cosine transform (DCT) , discrete Hartley transform (DHT) , discrete wavelet transform (DWT) , etc., may be employed. Image enhancement is subjective area of image processing. These techniques are used to highlight certain features of interest in an image. Two important examples of image enhancement are: (i) increasing the contrast, and (ii) changing the brightness level of an image so that the image looks better. Image restoration is one of the prime areas of image processing and it is very much objective .The restoration techniques are based on mathematical and statistical models of image degradation. Denoising and Deblurring tasks come under this category. Its objective is to recover the images from degraded observations. The techniques involved in image restoration are oriented towards modeling the degradations and then applying an inverse procedure to obtain an approximation of the original image. Hence, it may be treated as a deconvolution operation.

Depending on applications, there are various types of imaging systems. X-ray, Gamma ray, ultraviolet, and ultrasonic imaging systems are used in biomedical instrumentation. In astronomy, the ultraviolet, infrared and radio imaging systems are used. Sonic imaging is performed for geological exploration. Microwave imaging is employed for radar applications. But, the most commonly known imaging systems are visible light imaging. Such systems are employed for applications like remote sensing, microscopy, measurements, consumer electronics, entertainment electronics, etc.

B. Noise in digital images

In this section, various types of noise corrupting an image signal are studied, the sources of various noises are discussed, and mathematical models for these types of noise are shown. Note that noise is undesired information that contaminates the image.

An image gets corrupted with noise during acquisition, transmission, storage and retrieval processes. The various types of noise are discussed in this chapter.

Additive And Multiplicative Noises

For An efficient denoising technique, information about the type of noise presented in the corrupted image plays a significant role. Mostly images are corrupted with Gaussian, uniform, or salt and pepper distribution noise. Another considerable noise is a speckle noise. Speckle noise is multiplicative noise.

Let the original image f(x,y) and noise introduced is

$\eta = (x, y)$ and the corrupted image be w (x, y) where (x, y) gives us the pixel location.

Then, if image gets additive noise then the corrupted image will be

ω(x, y) = f(x, y) + $\eta(x, y)$

Similarly, if multiplicative noise is acquired during processing of image then the corrupted image will be

$$\omega(x, y) = f(x, y) * \eta(x, y)$$

The above two operations will be done at pixel level. The digital image acquisition process converts an optical image into a electrical signal which is continuous then sampled. At every step in the process there are fluctuations caused by natural phenomena, adding a random value to the given pixel value.

C. Peak Signal to Noise Ratio (PSNR)

And another important metric is Peak signal to noise ratio (PSNR). It is defined in logarithmic scale,in dB. It is a ratio of peak signal power to noise power. Since the MSE represents the noise power and the peak signal power, the PSNR is defined as:

$$PSNR = 10 * \log_{10} \frac{1}{MSE}$$

This image metric is used for evaluating the quality of a filtered image and thereby the capability and efficiency of a filtering process.

In addition to these metrics, universal quality index (UQI) is extensively used to evaluate the quality of an image now-a-days. Further, some parameters, e.g. method noise and execution time are also used in literature to evaluate the filtering performance of a filter.

III. LITERATURE REVIEW

S. Saxena, H. S. Khanduga, S. Mantri and S. Puri,[1] "An efficient denoising method based on SURE-LET and Wavelet Transform,"Our objective of this research work is to frame an efficient method based on wavelet so that sparsity and multi-resonate structure of wavelet properties can be used for Image Denosing. So fulfilling the objective to make an efficient Image Denoising technique we have proposed an Image denoising technique which is based on squared error-Stein's unbiased risk estimate linear expansion of thresholds (SURE-LET). This technique is a combination of SURE-LET and Wavelet Transform. This hybrid approach gives good result because the sparsity and multi-resonate properties of wavelet will fetch linear noise less relation matrix as well as related matrix. The SURE-LET can able to transform the unknown weight as well as the quadratic estimation with peak boundary values. The results are calculated and compared with the help of peak signal to noise ratio (PSNR) and mean square error (MSE). The comparative study suggests that our hybrid approach has outperformed from the previous approach.

B. Goossens, A. Pizurica and W. Philips,[2] "Image Denoising Using Mixtures of Projected Gaussian Scale Mixtures,"We propose a new statistical model for image restoration in which neighborhoods of wavelet subbands are modeled by a discrete mixture of linear projected Gaussian scale mixtures (MPGSM). In each projection, a lower dimensional approximation of the local neighborhood is obtained, thereby modeling the strongest correlations in that neighborhood. The model is a generalization of the recently developed Mixture of GSM (MGSM) model, that offers a significant improvement both in PSNR and visually compared to the current state-of-the-art wavelet techniques. However, the computation cost is very high which hampers its use for practical purposes. We present a fast EM algorithm that takes advantage of the projection bases to speed up the algorithm. The results show that, when projecting on a fixed data-independent basis, even computational advantages with a limited loss of PSNR can be obtained with respect to the BLS-GSM denoising method, while data-dependent bases of Principle Components offer a higher denoising performance, both visually and in PSNR compared to the current wavelet-based state-of-the-art denoising methods.

J. Portilla, V. Strela, M. J. Wainwright and E. P. Simoncelli,[3]"Image denoising using scale mixtures of Gaussians in the wavelet domain," We describe a method for removing noise from digital images, based on a statistical model of the coefficients of an overcomplete multiscale oriented basis. Neighborhoods of coefficients at adjacent positions and scales are modeled as the product of two independent random variables: a Gaussian vector and a hidden positive scalar multiplier. The latter modulates the local variance of the coefficients in the neighborhood, and is thus able to account for the empirically observed correlation between the coefficient amplitudes. Under this model, the Bayesian least squares estimate of each coefficient reduces to a weighted average of the local linear estimates over all possible values of the hidden multiplier variable. We demonstrate through simulations with images contaminated by additive white Gaussian noise that the performance of this method substantially surpasses that of previously published methods, both visually and in terms of mean squared error.

F. Luisier, T. Blu and M. Unser,[4] "A New SURE Approach to Image Denoising: Interscale Orthonormal

Wavelet Thresholding," This research work introduces a new approach to orthonormal wavelet image denoising. Instead of postulating a statistical model for the wavelet coefficients, we directly parametrize the denoising process as a sum of elementary nonlinear processes with unknown weights. We then minimize an estimate of the mean square error between the clean image and the denoised one. The key point is that we have at our disposal a very accurate, statistically unbiased, MSE estimate-Stein's unbiased risk estimate-that depends on the noisy image alone, not on the clean one. Like the MSE, this estimate is quadratic in the unknown weights, and its minimization amounts to solving a linear system of equations. The existence of this a priori estimate makes it unnecessary to devise a specific statistical model for the wavelet coefficients. Instead, and contrary to the custom in the literature, these coefficients are not considered random any more. We describe an interscale orthonormal wavelet thresholding algorithm based on this new approach and show its near-optimal performance-both regarding quality and CPU requirement-by comparing it with the results of three state-of-the-art nonredundant denoising algorithms on a large set of test images. An interesting fallout of this study is the development of a new, group-delay-based, parent-child prediction in a wavelet dyadic tree

M. Elad and M. Aharon, [5] "Image Denoising Via Sparse and Redundant Representations Over Learned Dictionaries," We address the image denoising problem, where zero-mean white and homogeneous Gaussian additive noise is to be removed from a given image. The approach taken is based on sparse and redundant representations over trained dictionaries. Using the K-SVD algorithm, we obtain a dictionary that describes the image content effectively. Two training options are considered: using the corrupted image itself, or training on a corpus of high-quality image database. Since the K-SVD is limited in handling small image patches, we extend its deployment to arbitrary image sizes by defining a global image prior that forces sparsity over patches in every location in the image. We show how such Bayesian treatment leads to a simple and effective denoising algorithm. This leads to a state-of-the-art denoising performance, equivalent and sometimes surpassing recently published leading alternative denoising methods.

A. Mouton, G. T. Flitton, S. Bizot, N. Megherbi and T. P. Breckon, [6]"An evaluation of image denoising techniques applied to CT baggage screening imagery. This research work investigates the efficacy of several popular denoising methods in the previously unconsidered context of Computed Tomography (CT) baggage imagery. The performance of a dedicated CT baggage denoising approach (alpha-weighted mean separation and histogram equalisation) is compared to the following popular denoising techniques: anisotropic diffusion; total variation denoising; bilateral filtering; translation invariant wavelet shrinkage and non-local means filtering. In addition to a standard qualitative performance analysis (visual comparisons), denoising performance is evaluated with a recently developed 3D SIFT-based analysis technique that quantifies the impact of denoising on the implementation of automated 3D object recognition. The study yields encouraging results in both the qualitative and quantitative analyses, with wavelet thresholding producing the most satisfactory results. The results serve as a strong indication that simple denoising will aid human and computerised analyses of 3D CT baggage imagery for transport security screening.

IV. PROBLEM STATEMENT

In this research work we have find out the way of betterment in the direction of denoising process. The main aim behind this research work is estimating the recovered image from the distorted or noisy image. Though many denoising algorithms have been published, there is scope for improvement! One of the objectives of the current research work is to show that the proposed denoising algorithms based upon DWT, can be applied successfully to enhance the characteristics of noisy images by the proper selection of filtering and thresholding methods. The advantages of Complex Wavelet Transform and Hyperanalytic Wavelet Transform over real standard wavelet transform. Provides more scope in the areas of image denoising and image compression. The second objective of the present work is extending the DWT implementation to Diversity Enhanced DWT. Denoising algorithms are implemented With various filtering methods. A new version of hyper analytic Wavelet Transform (HWT) is implemented with a zero order wiener filtering for image analysis.

V. CONCLUSIONS

Image denoising, using wavelet techniques are effective because of its ability to capture the energy of signal in a few high transform values, when natural image is corrupted by Gaussian noise. Wavelet thresholding, an idea that noise is removed by killing coefficient relative to some threshold. Out of various thresholding techniques soft- thresholding proposed by Donoho and Johnston is most popular. The use of universal threshold to denoise images in wavelet domain is known as VisuShrink, In addition, sub band adaptive systems have superior performance, such as Sure Shrink Bayes Shrink, Neigh Shrink. From the PSNR and UQI values, it is clear that Neigh Shrink filter giving better results under low noise variance conditions and fuzzy based shrinkage giving moderate results under medium and high noise variance conditions

As Speckle noise is inherent property of ultrasound images. From the above simulated values, neigh shrink yields good performance under low variances of noise. And in case of high noise variance, neigh shrink, bayes shrink and fuzzy based wavelet denoising technique give the good filtering performance. As execution time is another important image metric it is observed that bayes shrink and neigh shrink are taking more time (in seconds) than fuzzy based wavelet filter.

REFRENCES

[1] T. Blu and F. Luisier, "The SURE-LET Approach to Image Denoising," in IEEE Transactions on Image Processing, vol. 16, no. 11, pp. 2778-2786, Nov. 2007.doi: 10.1109/TIP.2007.906002.

[2] B. Goossens, A. Pizurica and W. Philips, "Image Denoising Using Mixtures of Projected Gaussian Scale Mixtures," in IEEE Transactions on Image Processing, vol. 18, no. 8, pp. 1689-1702, Aug. 2009.doi: 10.1109/TIP.2009.2022006.

[3] J. Portilla, V. Strela, M. J. Wainwright and E. P. Simoncelli, "Image denoising using scale mixtures of Gaussians in the wavelet domain," in IEEE Transactions on Image Processing, vol. 12, no. 11, pp. 1338-1351, Nov. 2003 doi: 10.1109/TIP.2003.818640.

[4] F. Luisier, T. Blu and M. Unser, "A New SURE Approach to Image Denoising: Interscale Orthonormal Wavelet Thresholding," in IEEE Transactions on Image Processing, vol. 16, no. 3, pp. 593-606, March 2007.doi: 10.1109/TIP.2007.891064.

[5] M. Elad and M. Aharon, "Image Denoising Via Sparse and Redundant Representations Over Learned Dictionaries," in IEEE Transactions on Image Processing, vol. 15, no. 12, pp. 3736-3745, Dec. 2006.doi: 10.1109/TIP.2006.881969.

[6] Michel Misiti, Yves Misiti, Georges Oppenheim, Jean-Michel Poggi, “Wavelets and their Applications”, Published by ISTE 2007 UK.

[7] J. Xu, K. Zhang, M. Xu, and Z. Zhou. An adaptive threshold method for image denoising based on wavelet domain. Proceedings of SPIE, the International Society for Optical Engineering, 7495:165, 2009.

[8] J. Portilla, V. Strela, M.J. Wainwright, and E.P. Simoncelli. Image denoising using scale mixtures of Gaussians in the wavelet domain. Image Processing, IEEE Transactions on, 12(11):1338-1351, 2003.

[9] F. Luisier, T. Blu, and M. Unser. A new SURE approach to image denoising: Interscale orthonormal wavelet thresholding. IEEE Transactions on Image Processing, 16(3):593-606, 2007.

[10] B.A. Olshausen and D.J. Field. Sparse coding with an overcomplete basis set: A strategy employed by V1? Vision research, 37(23):3311-3325, 1997.

[11] Rinci Shrivastava, Ravi Mohan and Atuliika Shukla, " Wavelet based Linear Gaussian Image Denoising Methods”, International Journal of Advanced Technology and Engineering Exploration (IJATEE), Volume-2, Issue-3, February-2015, pp.37-42.

[12] M. Elad and M. Aharon. Image denoising via sparse and redundant representations over learned dictionaries.IEEE Transactions on Image Processing, 15(12):3736- 3745, 2006.

[13] Mahesh Prasanna K, Shantharama Rai C, “Image Processing Algorithms- A Comprehensive Study”, International Journal of Advanced Computer Research (IJACR), Volume-4, Issue-15, June-2014, pp.532-539.

[14] Animesh Dubey, " Efficient Content based Image Retrieval (CBIR) Techniques: A Survey “, ACCENTS Transactions on Image Processing and Computer Vision (TIPCV), Volume-1, Issue-1, November-2015, pp.28-32.

[15] Ankita Saxena and Kailash Patidar, “An Improved linear threshold based Domain Denoising International Journal of Advanced Technology and Engineering Exploration (IJATEE), Volume-2, Issue- 12, November-2015 ,pp.163-169.

[16] R. Srinivas, Satarupa Panda, “Performance Analysis of Various Filters for Image Noise Removal in Different Noise Environment”, International Journal of Advanced Computer Research (IJACR), Volume-3, Issue-13, December-2013, pp.47-52.

[17] Harsimran Singh, Tajinder kaur, " Novel Method for Edge Detection for Gray Scale Images using VC++ Environment " , International Journal of Advanced Computer Research (IJACR), Volume-3, Issue-13, December-2013 ,pp.193-197.

[18] Anand Swaroop Khare, Ravi Mohan, Sumit Sharma, " Image Denoising based on Fourth-Order Partial Differential Equations: A Survey “, International Journal of Advanced Computer Research (IJACR), Volume-3, Issue-9, March-2013 , pp.98-101.

[19] Anand Swaroop Khare, Ravi Mohan, Sumit Sharma, " An Efficient Image Denoising Method based on Fourth- Order Partial Differential Equations " , International Journal of Advanced Computer Research (IJACR), Volume-3, Issue-9, March-2013 ,pp. 126-131.

[20] Meenal Jain, Sumit Sharma, Ravi Mohan Sairam, " Result Analysis of Blur and Noise on Image Denoising based on PDE ",International Journal of Advanced Computer Research (IJACR), Volume-2, Issue-7, December-2012 ,pp.70-77.

[21] AlAttar, M.A.; Motaal, A. G.; Osman, N. F.; Fahmy, A.S., "Performance Evaluation of Cardiac MRI Image Denoising Techniques," Biomedical Engineering Conference, 2008. CIBEC 2008. Cairo International, pp.1,4, 18-20 Dec. 2008.

[22] Li Hongqiao; Wang Shengqian, "A New Image Denoising Method Using Wavelet Transform," Information Technology and Applications, 2009. IFITA '09. International Forum on, vol.1, no., pp.111, 114, 1517 May 2009.

[23] Guo-Duo Zhang; Xu-Hong Yang; Hang Xu; Dong- Qing Lu; Yong-Xiao Liu, "Image Denoising Based on Support Vector Machine," Engineering and Technology (S-CET), 2012 Spring Congress on , pp.1,4, 27-30 May 2012.

[24] Liu Jinping; Gui Weihua; Tang Zhaohui; Mu Xuemin; Zhu Jianyong, "Spatial-temporal method for image denoising based on BLS-GSM in Curvelet transformation," Control Conference (CCC), 2012 31st Chinese , pp.4027,4032, 25-27 July 2012.

[25] Mouton, A.; Flitton, G.T.; Bizot, S.; Megherbi, N.; Breckon, T.P., "An evaluation of image denoising techniques applied to CT baggage screening imagery," Industrial Technology (ICIT), 2013 IEEE International Conference on , pp.1063,1068, 25-28 Feb. 2013.

[26] Parmar, J.M.; Patil, S.A., "Performance evaluation and comparison of modified denoising method and the local adaptive wavelet image denoising method," Intelligent Systems and Signal Processing (ISSP), 2013 International Conference on , pp.101,105, 1-2 March 2013.

[27] Yan Chen; Liu, K.J.R., "Image Denoising Games," Circuits and Systems for Video Technology, IEEE Transactions on , vol.23, no. 10, pp. 1704,1716, Oct. 2013.

[28] Thilagavathi, M.; Deepa, P., "An efficient dictionary learning algorithm for 3d Medical Image Denoising based on Sadct," Information Communication and Embedded Systems (ICICES), 2013 International Conference on , vol., no., pp.442,447, 21-22 Feb. 2013.

[29] De-An Huang; Li-Wei Kang; Wang, Y.-C.F.; Chia- Wen Lin, "Self-Learning Based Image Decomposition With Applications to Single Image Denoising," Multimedia, IEEE Transactions on , vol. 16, no.1, pp.83,93, Jan. 2014.