An Extensive Review on Efficient Denoising Method Transforms

Saman Tajwar[1], Prof. Tanveer[2]

[1]*Mtech. Research Scholar,* [2]*Research Guide*

Department of Computer Science and Engineering, All Saints College of Technology, Bhopal

Abstract - Image restoration and enhancement are fundamental problems in image processing. The principal purpose of restoration is to improve a corrupted image by using a priori knowledge of degradation rule while the goal of enhancement is to obtain a better image than the original one for a specific purpose. In brief, restoration is an objective process whereas enhancement is a subjective process. Image denoising, sometimes called noise removal or noise reduction, plays an important role to achieve those purposes. Denoising is a procedure which removes the existing noise in an image and minimizes the loss of information in a (supposed) clean image. Wavelet transform has been a popular research subject in many science and engineering areas as well as pure mathematics for the last two decades. In signal and image processing field, wavelet transform tends to replace the role of Fourier transform. Wavelet has been used in many kinds of image processing applications such as compression, image analysis, computer graphics and watermarking besides denoising. Those algorithms are served as low-level processing units in computer vision and pattern recognition fields. The main goal of image denoising is to enhance or restore a noisy image and help the other system (or human) to understand it better. In this research, some efficient approaches for image denoising using wavelet and SURE-LET transforms have discussed.

Keywords- Image Denoising, Image Processing, wavelet transform, SURE-LET transform.

I. INTRODUCTION

Image processing has got wide varieties of applications in computer vision, multimedia communication, television broadcasting, etc. that demands very good quality of images. The quality of an image degrades due to introduction of additive white Gaussian noise (AWGN) during acquisition, transmission/ reception and storage/ retrieval processes. It is very much essential to suppress the noise in an image and to preserve the edges and fine details as far as possible. In the present research work, efforts are made to explore efficient spatial-domain and transform-domain image filters that suppress noise quite effectively.

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.

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.

Image denoising is needed because a noisy image is not pleasant to view. In addition, some fine details in the image may be confused with the noise or vice-versa. Many image-processing algorithms such as pattern recognition need a clean image to work effectively. Random and uncorrelated noise samples are not compressible. Such concerns underline the importance of denoising in image and video processing.

II. IMAGE DENOISING METHODS

Images obtained from the real world are always mixed with noise. The noise brought in is derived from multiple sources. The imperfect instrument itself would produce a certain amount of noise when the image is taken. When transforming the optical signal into a digital signal, the pixel's value at specific location is dependent to the number of photons the corresponding captor has received. So the instability of the number of receiving photons can cause the production of noise. Moreover, during image's amplification and transmission, additional perturbations can be introduced by electronic devices and transmission lines.

There are several different types of noise in digital images. For instance, shot noise is generated by the random way photons are emitted from a light source especially when the light intensity is limited and it is usually characterized by Poisson distribution. Thermal noise, also known as dark current noise, is produced by thermal agitation of electrons at sensing sites and highly dependent on the sensor's temperature and the exposure time. Images with impulsive noise, which is generally caused by the malfunctioning of elements in the camera sensors or timing errors in the data transmission process, have bright pixels in dark areas and dark pixels in bright areas. And quantization noise often happens due to the errors when an analog signal is converted to a number of discrete digital values.

There are many different kinds of image denoising algorithms. They can be broadly classified into two classes:

- Spatial domain filtering
- Transform domain filtering

Spatial domain filtering refers to filtering in the spatial domain, while transform domain filtering refers to filtering in the transform domain.

Image denoising algorithms which use wavelet transforms fall into transform domain filtering.

Spatial domain filtering can be further divided on the basis of the type of filter used:

- Linear filters
- Non-Linear filters

An example of a linear filter is the Wiener filter in the spatial domain. An example of a non-linear filter is the median filter. Median filtering is quite useful in getting rid of Salt and Pepper type noise. Spatial filters tend to cause blurring in the denoised image. Transform domain filters tend to cause Gibbs oscillations in the denoised image.

Transform domain filtering can be further divided into three broad classes based on the type of transform used:

- Fourier transform filters
- Wavelet transform filters

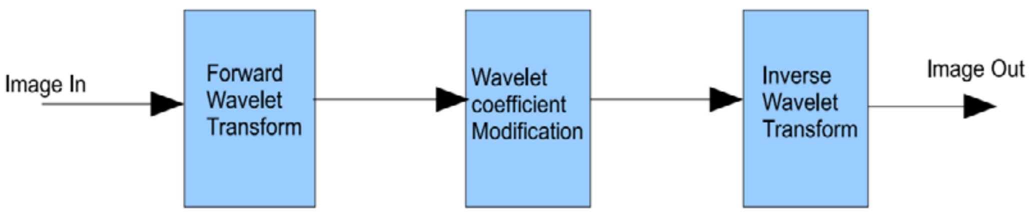

Figure 2.1 Denoising using Wavelet Transform Filtering.

Wavelet Transform

Wavelet transform is a great tool in image and signal processing. Many desnoising approaches using wavelet in the literature show that the wavelet is very efficient for image denoising. Unlike the Fourier transforms, the wavelet transform decomposes input data in terms of time and scale by basis wavelet function, called mother wavelet. So various types of wavelets with different properties could be designed. In addition, researchers have developed different types of approaches to reinforce the theory by filling up some possible deficiencies. For example, MRA theory has been combined with discrete wavelet transform (DWT) to play a critical role in image processing. Also filtering theory from signal processing makes the theory more fruitful. As a result, there exist numerous kinds of wavelet algorithms figure 2.1 demonstrate the basic image denoising using wavelet transform filtering.

- SURE- LET

The Thresholding algorithm SURE- LET. It directly simulates the denoising procedure as a linear combination of basis nonlinear processes with unknown weights. These weights are calculated via a linear system of equations by minimizing the mean square error between the clean image and the corrupted one based on the Stein's unbiased risk estimate (SURE). They also take full advantage of the interscale relationships of the wavelet coefficients by integrating an interscale predictor.

The SURE-LET has the best denoising performance among these four algorithms due to the fact that the threshold is subband adaptive and it is not dependent on any particular statistical model of the noise-free data. Meanwhile, its computation only takes a couple of seconds for 512 x 512 images, which makes it very competitive.

III. RELATED WORK

S. Saxena, H. S. Khanduga, S. Mantri and S. Puri,[1] 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.

H. Sadreazami, M. O. Ahmad and M. N. S. Swamy,[2] Statistical image modeling has attracted great attention in the field of image denoising. In this work, a new image denoising method in the contourlet domain is introduced in which the contourlet coefficients of images are modeled by using the Bessel k-form prior. A noisy image is decomposed into a low frequency approximation sub-image and a series of high frequency detail sub-images at different scales and directions via the contourlet transform. To estimate the noise-free coefficients in detail subbands, a Bayesian estimator is developed utilizing the Bessel k-form distribution. In order to estimate the parameters of the distribution, a characteristic function-based technique is used. Simulation results on standard test images show improved performance both in visual quality and in terms of the peak signal-to-noise ratio and structural similarity index as compared to some of the existing denoising methods. The proposed method also achieves an excellent balance between noise suppression and details preservation.

A. Kethwas and B. Jharia,[3] Nowadays images are very fundamental type data for transmission. In this research work, a mixed domain image denoising method based on the wavelet transform median filter and nonlinear diffusion are proposed. The wavelet transform is used to convert the spatial domain image to wavelet domain coefficients. Wavelet transform produces approximation, horizontal, vertical and diagonal detailed coefficient which represents the various spatial frequency bands. These coefficients may be filtered by wiener filter or fuzzy filter separately. One is based on median and moving average, while other one used on probabilistic way, respectively. Research work presents the two different techniques for image denoising, first technique is ATMAV (Asymmetrical Triangular Moving Average Filter) with HAAR wavelet transform and second is ATMED (Asymmetrical Triangular Median Filter) with HAAR wavelet transform. Both techniques are based on fuzzy logic based filters. Comparative analytical study based on PSNR and mean square error shows that HAAR with ATMED wavelet is better technique for image denoising.

K. Thakur, P. Ambhore, J. Kadam and A. Sapkal,[4] Medical imaging suffers from image noise. To remove this noise spatial domain and transform domain techniques are used. But spatial domain techniques have limitation of edge blurring w.r.t transform based techniques. Therefore in this research work have proposed a transform based denoising technique. Used Dual tree DWT and Rotated version of Dual Tree DWT jointly to improve our denoising results. Our main focus is to get more directional information from this transform which will improve denoising results. Compared our results with existing methods and results are very encouraging. PSNR is used as image quality measure.

H. Sadreazami, M. O. Ahmad and M. N. S. Swamy,[5] A new contourlet-based method is introduced for reducing noise in images corrupted by additive white Gaussian noise. This method takes into account the statistical dependencies among the contourlet coefficients of different scales. In view of this, a non-Gaussian multivariate distribution is proposed to capture the across-scale dependencies of the contourlet coefficients. This model is then exploited in a Bayesian maximum a posteriori estimator to restore the clean coefficients by deriving an efficient closed-form shrinkage function. Experimental results are performed to evaluate the performance of the proposed denoising method using typical noise-free images contaminated by simulated noise. The results show that the proposed method outperforms some of the state-of-the-art methods in terms of both the subjective and objective criteria.

F. Ayari and C. Ben Amar,[6] Analysis of material microstructure images have been an important research topic. In fact, multiple pertinent information can be extracted from material texture images such as inclusions, fraction surfaces, heterogeneous components, crystallographic planes orientation, porosity and so on. Actually, this information depends from the amount of noise included in the image. Thus, it is very important to enhance methods exploited for image de-nosing in such cases. In fact, images issued from scanned electronic microscopy as well as computed tomography are used in multiple security applications such as baggage screening and in the encrypted domain, it used to protect privacy of outsourced data in cloud computing. In this research work, propose a comparative study between two popular techniques used in image de-noising that are; Sure-let wavelet technique and weighted bilateral filtering. Our goal is to grasp the versatility of those methods in de-noising microstructure composite material images. Results of both outputs are well discussed. In our case, found that sure-let wavelet de-noising gives better output results quantitatively and qualitatively.

IV. PROBLEM STATEMENT

Image denoising attempts to recover a noise-free image by eliminating or reducing the noise on the observed image. This processing can be modeled as obtaining an optimal estimate of the unknown noise-free image from the available noise-corrupted image. A large number of scientific literatures have emphasized on image denoising in the last decade and there is still existing a wide range of interest in the subject nowadays. Although various algorithms and tools have been proposed, derived and improved, the problem is that many denoising techniques always suffer over-softening the crucial image features as well as introducing artifacts. Thus the searching for an efficient image denoising method is still a challenging task.

V. CONCLUSION

Various image denoising algorithms and methods used for image denoising has discussed in the research. Several well known algorithms for denoising natural images were investigated such as spatial domain filtering, Transform domain filtering image denoising methods and their algorithms. The performance evaluated using the literature review and past outcome or exceeding the performance of other algorithms. There are different types of noises that may corrupt a natural image in real life, such as shot noise, amplification noise, quantization noise etc. However, only zero-mean additive white Gaussian noise was considered because of it's simplicity. A major part of the research refers to the review, and performance assessment of past image denoising algorithms based on various techniques including the Wavelet transform.

REFERENCES

[1] S. Saxena, H. S. Khanduga, S. Mantri and S. Puri, "An efficient denoising method based on SURE-LET and Wavelet Transform," 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai, 2016, pp. 918-923.

[2] H. Sadreazami, M. O. Ahmad and M. N. S. Swamy, "Contourlet domain image denoising based on the Bessel k-form distribution," 2015 IEEE 28th Canadian Conference on Electrical and Computer Engineering (CCECE), Halifax, NS, 2015, pp.

[3] A. Kethwas and B. Jharia, "Image de-noising using fuzzy and wiener filter in wavelet domain," 2015 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), Coimbatore, 2015, pp. 1-5.

[4] K. Thakur, P. Ambhore, J. Kadam and A. Sapkal, "A combined approach for noise reduction in medical images using Dual Tree Discrete Wavelet Transform and Rotated Dual Tree Discrete Wavelet Transform," 2015 International Conference on Industrial Instrumentation and Control (ICIC), Pune, 2015, pp. 1003-1007.

[5] H. Sadreazami, M. O. Ahmad and M. N. S. Swamy, "Image denoising utilizing the scale-dependency in the contourlet domain," 2015 IEEE International Symposium on Circuits and Systems (ISCAS), Lisbon, 2015, pp. 2149-2152.

[6] F. Ayari and C. Ben Amar, "Image de-noising of a metal matrix composite microstructure using Sure-let wavelet and weighted bilateral filter," 2015 11th International Conference on Information Assurance and Security (IAS), Marrakech, 2015, pp. 146-151.

[7] 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.

[8] 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.

[9] 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.

[10] 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.

[11] 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.

[12] 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.

[13] 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.

[14] 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.

[15] 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.

[16] 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.

[17] 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.

[18] 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.

[19] 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.

[20] 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.

[21] 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, 15¬17 May 2009.

[22] 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.

[23] 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.