Journal of Theoretical and Applied Information Technology
15th September 2022. Vol.100. No 17

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

NSCT BASED PCA AND K-MEANS CLUSTERING BLOCK LEVEL APPROACH FOR SAR IMAGE DE-NOISING

DAWAR HUSAIN, DR. MUNAUWER ALAM

Integral University Lucknow INDIA

E-mail: mtechebrains@gmail.com

ABSTRACT

Visual data are transmitted as the high quality digital images in the major fields of communication in all of the modern applications. These images on receiving after transmission are most of the times corrupted with noise. This thesis focused on the work which works on the received image processing before it is used for particular applications. We applied image denoising which involves the manipulation of the Nonsubsampled Contourlet Transform (NSCT) coefficients of noisy image data to produce a visually high standard denoised image. This works consist of extensive reviews of the various parametric and non parametric existing denoising algorithms based on statistical estimation approach related to wavelet transforms connected processing approach and contains analytical results of denoising under the effect of various noise at different intensities .These different noise models includes additive and multiplicative types distortions in images used. It includes Gaussian noise and speckle noise. The denoising algorithm is application independent and giving a very high speed performance with desired noise less image even in the presence of high level distortion. Hence, it is not required to have prior knowledge about the type of noise present in the image because of the adaptive nature of the proposed denoising algorithm.

Keywords- *Image - Denoising, NSCT, Gaussian Noise , PCA ,K Mean Clustering.*

1 INTRODUCTION:

The performance of image-denoising algorithms using wavelet transforms can be improved significantly by taking into account the statistical dependencies among wavelet coefficients as demonstrated by several algorithms presented in the literature. The performance can also be improved using simple models by estimating model parameters in a local neighborhood. Some recent research has addressed the development of statistical models of wavelet coefficients of natural images and application of these models to image denoising [5]. Recently, highly effective yet simple schemes mostly based on soft thresholding have been developed [1]. In [10], the wavelet coefficients are modeled with a Gaussian a priori density, and locally adaptive estimation is done for coefficient variances. Also, prior knowledge is taken into account to estimate coefficient variances more accurately. In [1], the interscale dependencies are used to improve the performance. In [2], the simple soft-thresholding idea is used for each of the wavelet subbands, and the threshold value is estimated to minimize the mean-square error. The models that exploit the dependency between coefficients give better results compared to the ones using an independence assumption [5]. However, some of these models are complicated and result in high computational cost. In [12], a bivariate probability density function (pdf) is proposed to model the statistical dependence between a coefficient and its parent, and the corresponding bivariate shrinkage function is obtained. This new rule maintains the simplicity, efficiency, and intuition of soft thresholding. An explicit multivariate shrinkage function for wavelet denoising is also presented in [4]. In this letter, the local adaptive estimation of necessary parameters for the bivariate shrinkage function will be described. Also, the performance of this system will be demonstrated on both the orthogonal wavelet transform.

We developed an image de-noising algorithm using PCA scheme to decompose the noise with additive or multiplicative nature. A signal dependent noise model, is derived by LMMSE approach for solving PCA-based denoising problems using the NCST coefficients. This approach is new in NSCT-PCA-KNN based denoising method on the signal dependent noise

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

model for denoising of Synthetic aperture radar (SAR) image that instead of block processing based similarity employed a clustering approach using KNN. The image de-noising is performed for salt and pepper noise and AWGN noise. However it is the synthetic noise added in simulation. The simulation performance may be tested in the real time noise conditions added due to channel fading or inappropriate weather conditions etc. Although transform in frequency domain methods related denoising is proved to be efficient than filtering method but the limitations lies in the inadequate representation of local spatial objects in images by the fixed frequency band basis of NSCT.

SAR images are produced by coherent imaging system that suffers from speckle noise and AWGN having granular appearance and greatly distorts the visual interpretation and enhancement due to image processing schemes . Generally multilook averaging is a common method for such type of noise suppression but it degrades the spatial resolution another methods are associated with incorporation of development for filtering techniques. This article is also focused on denoising of SAR images by developing a signal-dependent noise model that takes into account this particularity by applying NSCT based frequency decomposition , PCA based extraction of useful information and KNN base clustering of distorted regions.
Information technology is getting advanced day by day due to evolution of data type used in modern world applications. Data is not limited to text or numeric values but maximum users are using multimedia data to communicate. The image data is getting most frequent information that is stored or transfer in defense, satellite, lab research, medical applications. Modern machine learning methods are extracting information for establishing robust decision making system in all the fields. The extracted information are useless if it is erroneous. The error are significantly due to the noise present in the environment or internal hardware component. Hence the denoising algorithms are required with higher performance for image data. This article contributes a novel scheme that gives an alternative to filter methods based on block processing. This helps in defining a different denoising scheme that reduces the noise and hence minimizes the errors occurs in value of features extracted from image data type information.

2. LITERATURE REVIEW:

Recently, the dual-tree complex wavelet transform has been proposed by Alin Achim et. al. (2005) [8], as a novel analysis tool featuring near shift-invariance and improved directional selectivity compared to the standard wavelet transform. Within this framework, we describe a novel technique for removing noise from digital images. We design a bivariate maximum a posteriori estimator, which relies on the family of isotropic -stable distributions. Using this relatively new statistical model we are able to better capture the heavy-tailed nature of the data as well as the interscale dependencies of wavelet coefficients. We test our algorithm for the Cauchy case, in comparison with several recently published methods. The simulation results show that our proposed technique achieves state-of-the-art performance in terms of root mean squared error.

Aleksandra Pizurica and Wilfried Philips (2006) [9], they develop three novel wavelet domain denoising methods for subband-adaptive, spatially-adaptive and multivalued image denoising. The core of our approach is the estimation of the probability that a given coefficient contains a significant noise-free component, which we call “signal of interest.” In this respect, we analyze cases where the probability of signal presence is 1) fixed per subband, 2) conditioned on a local spatial context, and 3) conditioned on information from multiple image bands. All the probabilities are estimated assuming a generalized Laplacian prior for noise-free subband data and additive white Gaussian noise. The results demonstrate that the new subband-adaptive shrinkage function outperforms Bayesian thresholding approaches in terms of mean-squared error. The spatially adaptive version of the proposed method yields better results than the existing spatially adaptive ones of similar and higher complexity. The performance on color and on multispectral images is superior with respect to recent multiband wavelet thresholding.

This work introduced by Florian Luisier et. al. (2007) [3], 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

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

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 anymore. 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.

This work presentd by Hossein Rabbani (2009) [7] a new image denoising algorithm based on the modeling of coefficients in each subband of steerable pyramid employing a Laplacian probability density function (pdf) with local variance. This pdf is able to model the heavy-tailed nature of steerable pyramid coefficients and the empirically observed correlation between the coefficient amplitudes. Within this framework, we describe a novel method for image denoising based on designing both maximum a posteriori (MAP) and minimum mean squared error (MMSE) estimators, which relies on the zero-mean Laplacian random variables with high local correlation. Despite the simplicity of our spatially adaptive denoising method, both in its concern and implementation, our denoising results achieves better performance than several published methods such as Bayes least squared Gaussian scale mixture (BLS-GSM) technique that is a state-of-the-art denoising technique.

A new method based on the curvelet transform is proposed by Qiang Guo et. al. (2010), [11] for image denoising. This method exploits a multivariate generalized spherically contoured exponential (GSCE) probability density function to model neighboring curvelet coefficients. Based on the multivariate probability model, which takes account of the dependency between the estimated curvelet coefficients and their neighbors, a multivariate shrinkage function for image denoising is derived by maximum a posteriori (MAP) estimator. Experimental results show that the proposed method obtains better performance than the existing curvelet-based image denoising method.

Innovative tactics are employed by terrorists to conceal weapons and explosives to perpetrate violent attacks, accounting for the deaths of millions of lives every year and contributing to huge economic losses to the global society. Achieving a high threat detection rate during an inspection of crowds to recognize and detect threat elements from a secure distance is the motivation for the development of intelligent image data analysis from a machine learning perspective. A method proposed to reduce the image dimensions with support vector, linearity and orthogonal. The functionality of CWD is contingent upon the plenary characterization of fusion data from multiple image sensors. Ammar Wisam Altaher et. Al. (2020) [13], proposed method combines multiple sensors by hybrid fusion of sigmoidal Hadamard wavelet transform and PCA basis functions. Weapon recognition and the detection system, using Image segmentation and K means support vector machine A classifier is an autonomous process for the recognition of threat weapons regardless of make, variety, shape, or position on the suspect's body despite concealment.

Jinan N. Shehab, and Hussein A. Abdulkadhim (2021) [14] presented unsupervised change detection method to produce more accurate change map from imbalanced SAR images for the same land cover. This method is based on PSO algorithm for image segmentation to layers which classify by Gabor Wavelet filter and then K-means clustering to generate new change map. Tests are confirming the effectiveness and efficiency by comparison obtained results with the results of the other methods. Integration of PSO with Gabor filter and k-means will providing more and more accuracy to detect a least changing in objects and terrain of SAR image, as well as reduce the processing time.

3. Methodology:

In the convention approach of work first of all we have performed wavelet decomposition on the noisy image, then the estimation the noise-free NSCT coefficients is performed by using the Bayesian model based estimation. The Bayesian

estimation process is performed by calculating a probability density function (pdf) for modeling of the NSCT coefficients of the denoised image. The denoised image is reconstructed by using the inverse transform (INSCT).
In this work we have not used above mentioned previous approaches called as parametric model-based based approach in which the formulation of the marginal distribution of wavelet coefficients is performed. Our proposed work is non-parametric contourlet coefficients model which can automatically adapts to the image data, in this way it can proved to be better in performance in respect of the conventional parametric model approaches which uses a models that has fixed formulation calculated in advance. Furthermore, in our approach a maximum a posteriori (MAP) estimation-based denoising method is used by incorporating the proposed model of the Bayesian eestimation framework.
A non-parametric statistical model to formulate the distribution of contourlet coefficients followed by the derivation of the proposed MAP estimation-based image denoising approach. Experimental results are provided to show that the proposed MAP estimation-based image denoising algorithm outperforms the conventional algorithms.

Literatures that has used classical filters for denoising of SAR images in spatial domain by considering the center pixels in filter windows on the basis of local scene heterogeneity. Such approach suits the stationary image. It either preserve noise or erase a weak signal at boundary lines of image objects. For better preservation of boundary objects of image. Speckle reduction anisotropic diffusion methods are proposed that are sensitive to object boundaries on applying the conventional filters.The gamma MAP filter [5], denoising for SAR image using maximum *a posteriori* criteria, calculation through gamma distribution describes the SAR image objects accurately. It has proved that more efficient denoising may be achieved in transformed domain that incorporates the capability of decomposing signal and noise components. The wavelet coefficient based approach mainly reduces the high-frequency noise by suppressing detail components. This is useful in denoising the AWGN [6-10]. But the denoising performance has high sensitivity to transform operation and distortion of the radiometric properties are observed in SAR image that may be minimized by additive signal dependent noise models [11]–[14].

3.5.1 Proposed Image Denoising Approach:

A PCA in hybrid with clusterong approach is applied in this work for performing image denoising. If the noisy contourlet coefficient are found for a noisy image (yi, where ‘i’ is the index), the objective is to recover the noise-less contourlet coefficient (si) via PCA analysis formulae.
The proposed approach uses 2-D NSCT decomposition using a Daubechies’s contourlet of noisy image for calculating noisy contourlet coefficients. Then, the proposed approach applies mathematical approach developed on MATLAB for the calculation of each noise-free components excluding those of the LL subband. Finally, the inverse contourlet transform is applied to obtain the denoised image.

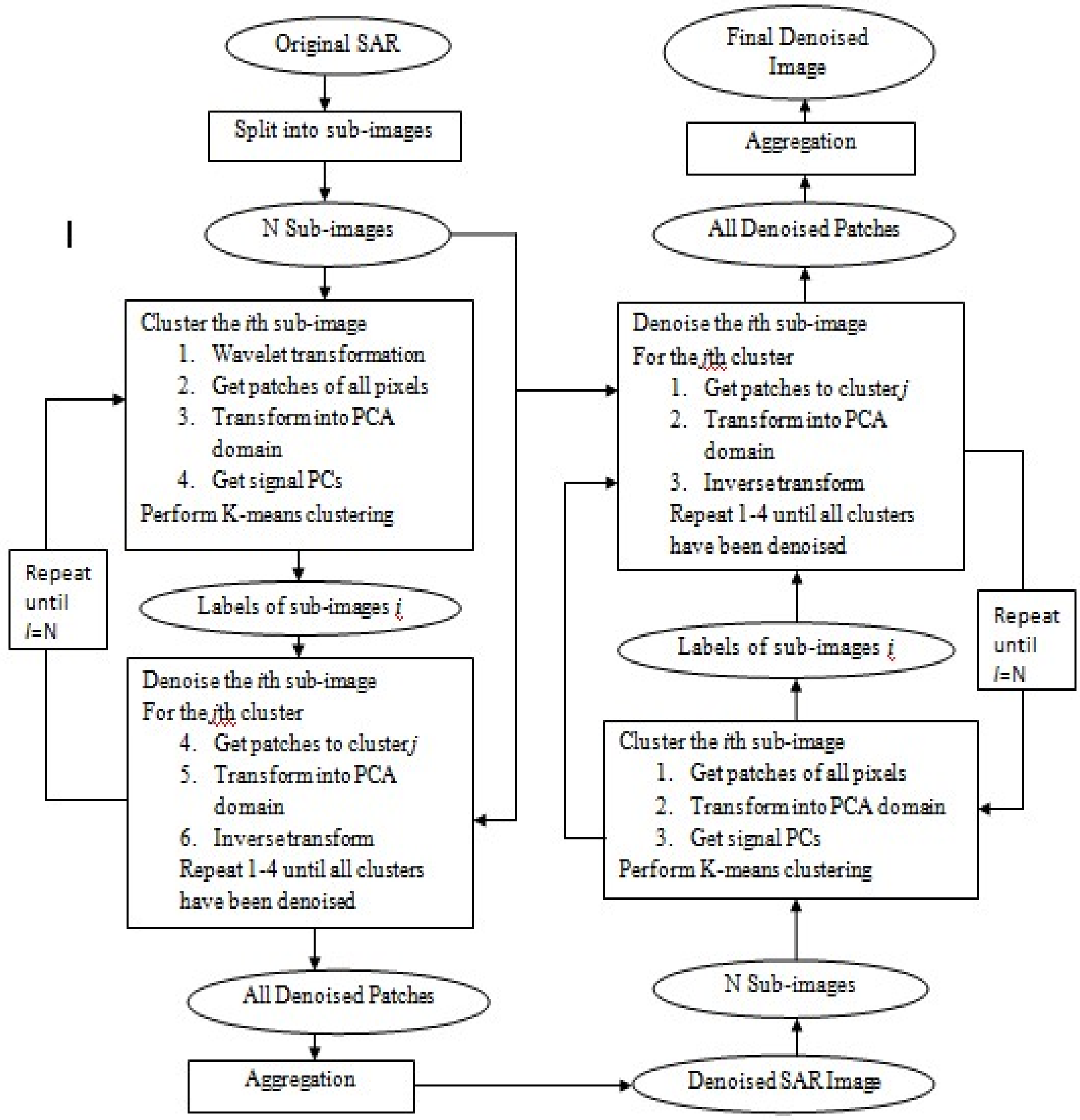

Fig 1: Flow Chart

4. RESULT AND DISCUSSION:

In this work we are working on different SAR images obtained from various website links. We added two types of noises on these two images and after that denoising procedure applied on them with different Mean variance and density. There are two types of noise which we add in our images:

1. Gaussian
2. Speckle

we calculate the PSNR value by changing the value of mean, variance ((0, 0.001) to (0, 0.1)) and density (0.001 to 0.1).

In figure 2(a) first of all the original image is shown.It is a satellite view of area with green area and buildings. The image is gray scale image. Such image are covering broad geographical aera from very large distance of capturing. It consist of distorted overview of small objects. This image is further distorted by Gaussian noise at mean 0.001 and variance 0.005 as shown in figure 2a (middle).The noisy image is showing presence of small granular distortions of uneven shapes. This noise is passed through the proposed approach of NSCT-PCA-KNN based denoising. The PSNR in between denoised image and original image in

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

figure 2a (rigth) the denoised image and its PSNR is shown. The PSNR is found to be 26.150.Hence it is a high PSNR value and representing perfect similarity of denoised image to original image. This original image is then distorted by speckle noise at noise density of 0.1 as shown in figure 2b (middle).The noisy image is deteriorated with small granular distortions of even shapes. This noise is passed through the proposed approach.The PSNR and denoised image in figure 2b (right) is found to be 25.Again it is giving a high PSNR and proof of perfect denoising in presence of speckle noise.

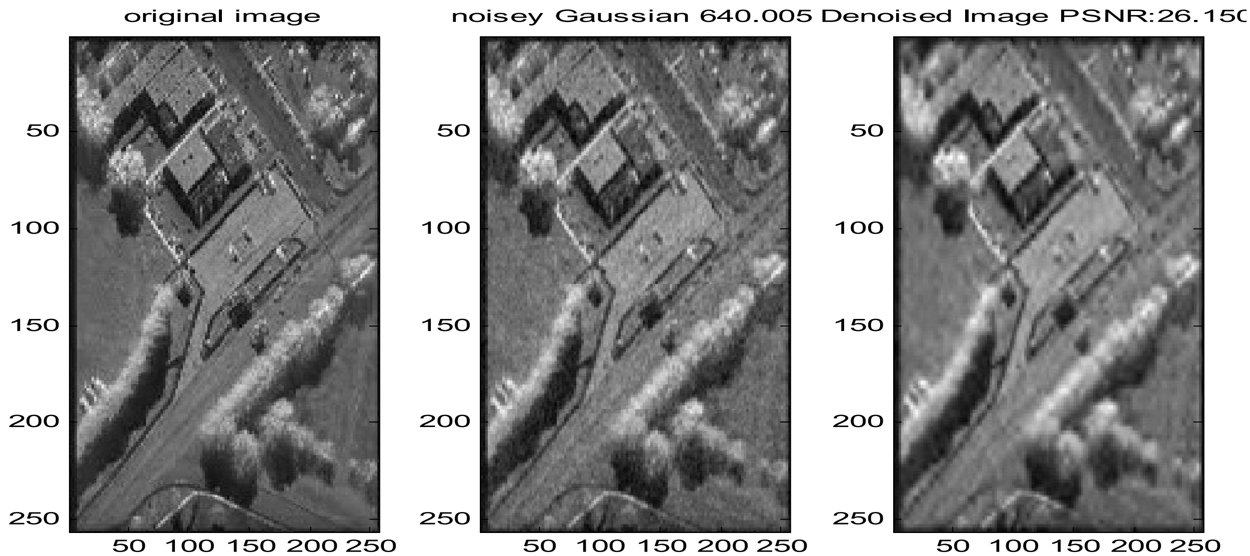

Figure2(a):Original,noisy and denoised SAR image 001.jpg for Gaussian noise at mean 0.001 and variance 0.005.

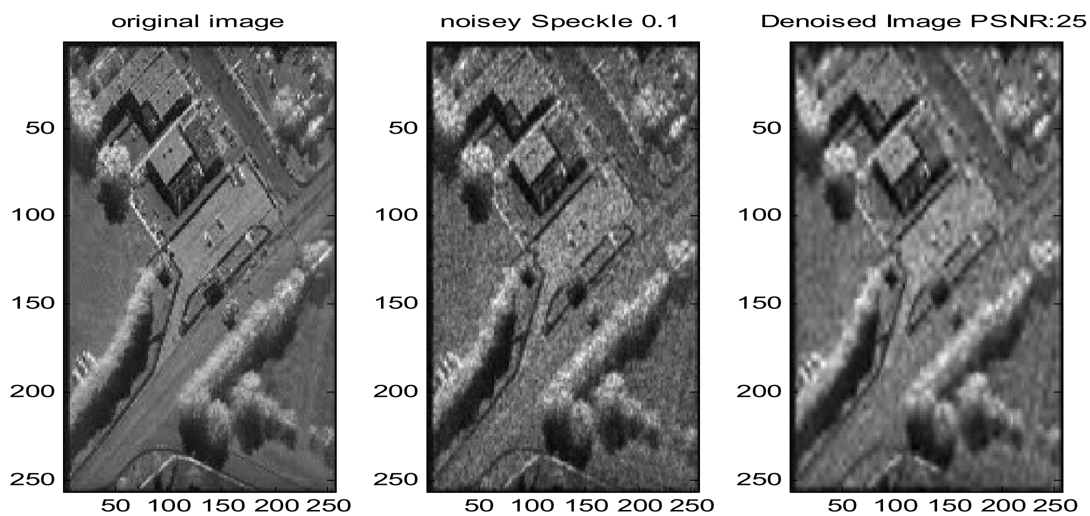

Figure 2(B):Original,Noisy And Denoised SAR Image 001.Jpg For Speckle Noise At Noise Density 0.1.

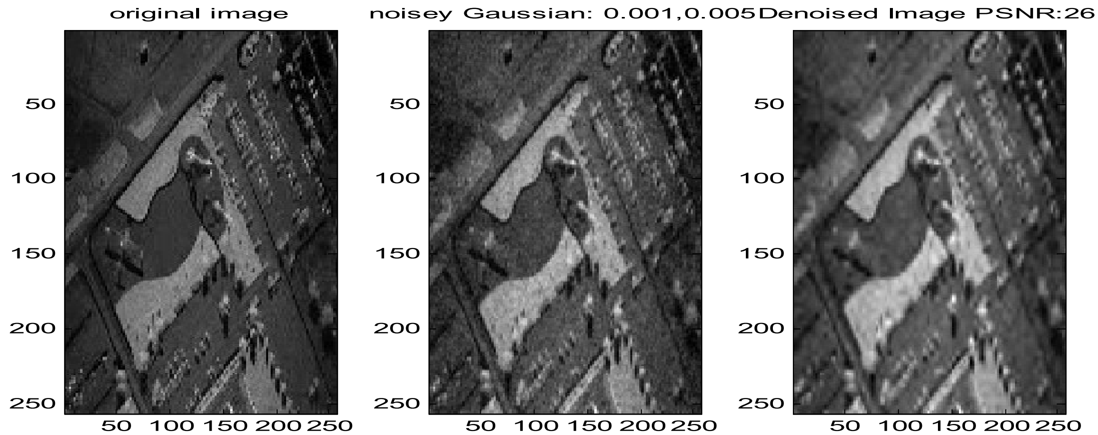

Figure 3(A):Original,Noisy And Denoised SAR Image 1.Jpg For Gaussian Noise At Mean 0.001 And Variance 0.005.

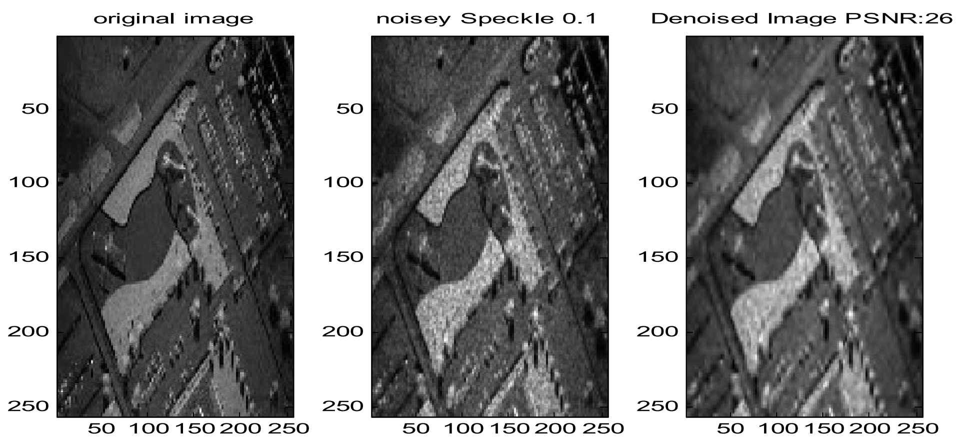

Figure 3(B): Original, Noisy And Denoised SAR Image 1.Jpg For Speckle Noise At Noise Density 0.1

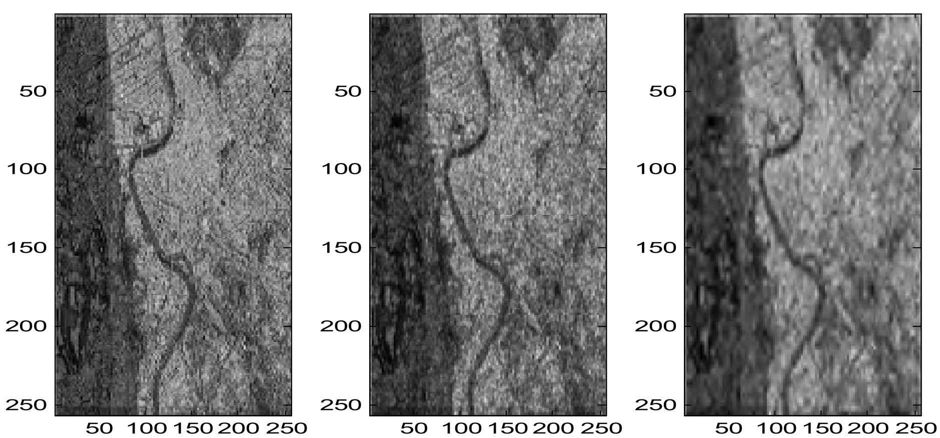

Figure 4(A):Original,Noisy And Denoised SAR Image 06.Jpg For Gaussian Noise At Mean 0.001 And Variance 0.005.

Journal of Theoretical and Applied Information Technology
15th September 2022. Vol.100. No 17

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

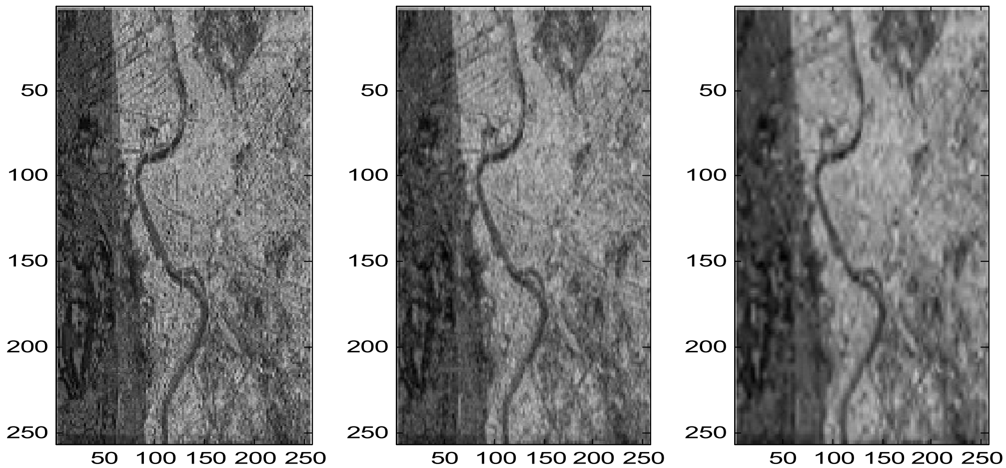

Figure 4(B):Original,Noisy And Denoised SAR Image 06.Jpg For Speckle Noise At Noise Density 0.1

Similar to figure 2(a,b) the proposed algorithm is also tested for images shown in figure 3,4 (a and b).Theese images are randomly taken from websites.Most of the images are of low resolution and considered to be taken in non ideal weather and irradiance conditions. Performance are again evaluated for AWGN and speckle noise and the PSNR value for figure 4(a and b) are 26 and for the figure 4 (a.b) the PSNR is 25. Results are evaluated for remaining 15 image and results are tabulated as shown below. All the results in table are showing the algorithm performance in terms of PSNR in presence of the AWGN or speckle noise.It has been observed that the minimum PSNR for AWGN is found to be 25 and maximum is 29.Simlarly the PSNR in between denoised image and original image under the distortions due to speckle noise has minimum value of 25 and maximum of 26.In this way the observed results are showing acceptable performance.

Table : PSNR Results For After Denoising Of Various SAR Image **.**

Image No.	PSNR for Gaussian Noise	PSNR for Speckle Noise
1	26	25
2	26	26
3	25	25
4	25	25
5	26	24
6	26	25
7	26	24
8	27	26
9	26	25
10	28	26
11	29	27
12	26	24
13	25	25
14	26	25
15	28	26

5. CONCLUSION:

We have performed comparative analysis of the results of proposed algorithm to various image denoising techniques from the different literature results on standard images. In our implementation the bivariate PCA analysis function is applied alongwith k-mean clustering to the magnitude of the NSCT coefficients, which is more shift invariant than the real or imaginary parts. To measure the denoising performance of the improved algorithm we applied the peak signal-to-noise ratio (PSNR).We compared our proposed algorithm to other effective techniques from the different literatures using the standard images. In this work estimation of noise free coefficients is applied to the values of the NSCT coefficients of SAR image. We have currently explored the algorithm performance on several images at the effects of different types of noise effect at different noise intensity. In future we can proceed in a direction for the further improvement of the denoising statistical image model by consideration of the other non parametric bivariate-stable distributions. The implementation can be performed by a method of employing isotropic stable densities provided that we are equipped with an efficient mechanism for computing bivariate densities. We can also consider intrascale dependencies of contourlet coefficients by means random fields to significantly improve the overall performance of a denoising algorithm in future.

The real SAR images randomly collected from different websites with low resolution are tested for proposed denoising scheme. The default patch size parameters of 3 × 3 for the proposed schemes gives the best tradeoffs between removal of noise and preservation of boundary line details. The proposed algorithm based on SDN model greatly suppress the noise. All the denoised images are smooth and preserve image details very well. The current research work applied PCA for data decomposition in normal and noisy component as the significant and insignificant information.PCA explores linear relationship however other decomposition methods are now available that may perform decomposition using non linear parameters. If such decompositions are added then better extraction of natural noisy data may be performed.

MAJOR ACHIEVEMENT:

The proposed denoising approach achieved clean images
without smoothing out the details. The NSCT-PCS-K mean
specifically designed for SAR image denoising helps to remove dark artifacts with smoother irrespective to noise heterogeneity.

REFERENCES:

[1] Z. Cai, T. H. Cheng, C. Lu, and K. R. Subramanian, "Efficient waveletbased image denoising algorithm," Electron. Lett., vol. 37, no. 11, pp. 683–685, May 2001.

[2] S. Chang, B. Yu, and M. Vetterli, "Adaptive wavelet thresholding for image denoising and compression," IEEE Trans. Image Processing, vol. 9, pp. 1532–1546, Sept. 2000.

[3] F. Luisier, T. Blu, and M. Unser, "A new SURE approach to image denoising: Interscale orthonormal wavelet thresholding," IEEE Trans. Image Process., vol. 16, pp. 593-606, 2007.

[4] T. Cai and B.W. Silverman, "Incorporating information on neighboring coefficients into wavelet estimation," Sankhya, vol. 63, pp. 127–148, 2001.

[5] M. S. Crouse, R. D. Nowak, and R. G. Baraniuk, "Wavelet-based signal processing using hidden Markov models," IEEE Trans. Signal Processing, vol. 46, pp. 886–902, Apr. 1998.

[6] D. L. Donoho and I. M. Johnstone, "Ideal spatial adaptation by wavelet shrinkage," Biometrika, vol. 81, no. 3, pp. 425–455, 1994.

[7] H. Rabbani, "Image denoising in steerable pyramid domain based on a local Laplace prior," Pattern Recognition, vol. 42, pp. 2181-2193, 2009.

[8] A. Achim and E. E. Kuruoglu, "Image denoising using bivariate α-stable distributions in the complex wavelet domain," IEEE Signal Process. Lett., vol. 12, pp. 17-20, 2005.

[9] A. Pizurica and W. Philips, "Estimating the probability of the presence of a signal of interest in multiresolution single- and multiband image denoising," IEEE Trans. Image Process., vol. 15, pp. 654-665, 2006.

[10] M. K. Mihcak, I.Kozintsev, K. Ramchandran, and P. Moulin, "Low-complexity image denoising based on statistical modeling of wavelet coefficients," IEEE Signal Processing Lett., vol. 6, pp. 300–303, Dec. 1999.

[11] Q. Guo and S. Yu, "Image denoising using a multivariate shrinkage function in the curvelet domain," IEICE Electron. Express, vol. 7, pp. 126-131, 2010.

[12] L. Sendur and I. W. Selesnick, "A bivariate shrinkage function for wavelet based denoising," in IEEE ICASSP, 2002.

[13] Ammar Wisam Altaher et. al., "Image processing analysis of sigmoidal Hadamard wavelet with PCA to detect hidden object", TELKOMNIKA Telecommunication, Computing, Electronics and Control Vol. 18, No. 3, June 2020, pp. 1216~1223.

[14] Jinan N. Shehab, and Hussein A. Abdulkadhim, "Performance of Unsupervised Change Detection Method Based on PSO and K-means Clustering for SAR Images", Intl Journal Of Electronics And Telecommunications, 2021, VOL. 67, NO. 3, PP. 403-408.

[15] Jin Liu, Zilu Wu, Qi Li " A Novel Local Feature Extraction Algorithm Based on Gabor Wavelet Transform", ICAIP 2019: Proceedings of the 2019 3rd International Conference on Advances in Image Processing.

[16] David Bařina, "Gabor Wavelets in Image Processing", Proceedings of conference and competitions student EEICT 2011, Czech Republic, pp. 1-5.

[17] Deepak Verma, Dr. Vijaypal Dhaka, Shubhlakshmi Agrwa, "An Improved Average Gabor Wavelet Filter Feature Extraction Technique for Facial Expression Recognition", International Journal of Innovations in Engineering and Technology (IJIET), Vol. 2 Issue 4 August 2013, pp. 35-41.

[18] Youguo Li, Haiyan Wu, " A Clustering Method Based on K-Means Algorithm", 2012 International Conference on Solid State Devices and Materials Science