IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 13, Issue 6, Ver. I (Nov.-Dec. 2018), PP 27-34
www.iosrjournals.org

HRFA Based Image Denoising With Edge Preserve Segmentation

K.M.Hemambaran[1], Dr. S.A.K. Jilani[2]
[1](Research Scholar, ECE Department, Rayalaseema University, Kurnool)
[2](Professor, ECE Department, MITS, Madanapalle)
Corresponding Author: K.M.Hemambaran

Abstract: *Denoising of images is an emerging technique in the present day research works, since it is used in the various processing in image. Considerably, the denoising of image is a method in which the image is restored by removing the unwanted distortions or noises from the image in order to obtain a high visually enhanced image. But existing denoising algorithms mainly focus on the noise reduction instead of focusing on the edge preserving. Hence the finally obtained image is of low quality. Therefore in our paper we proposed to eliminate the noise such as zero mean white Gaussian noise from the image by using the high resolution frequency analysis. For this process we calculate the texture features of the image in order to implement the segmentation make possible in noisy image. Hence, we implement different segmentation techniques for different images corrupted with different noise in order to obtain the efficient segmented image. In our paper we implement mean shift clustering for segmentation of object from the image. In addition to this segmentation we also use edge segmentation technique with different parameters. And then the non uniform regions obtained from the segmentation process are analyzed based on the Mask NHA which is an extended version of 2D NHA. However, the calculation of the different parameter values takes more time and it is not an easy job. After studying and conducting experiments on the image by using Mask NHA method it is noticed that this method provides valid and better results compared to state of art methods such as BM3D and LRF.*
Index terms: *Image processing, 2D-NHA, Segmentation, Edge regions, Mask NHA*

Date of Submission: 04-12-2018 Date of acceptance: 20-12-2018

I. Introduction

Denoising of an image is the process of eliminating the noise from the image by applying various noise removing algorithms. From this we obtain a denoised image which can be used for other image processing applications. The main purpose this algorithm is to obtain the image by removing the unwanted signal by preserving the edges [1]. In present conditions the digital images are used in the many applications such as satellite television, biomedical applications such as MRI, CT scanning etc, computer tomography and geographical information systems. In general, the images acquired by the sensors are affected by the noise [2]. But, due to these sensors the data in the image may be corrupted due to defects that occur in that devices, data requirement problems and phenomenon hindrance. In fact noise is also occurred due to the transmission and compression techniques. Therefore denoising the image is the starting procedure for the way to reduce the corruption in the data [3]. But still the image denoising is a challenging technique since the removal of noise may cause blur in images.

Image denoising is the foremost technique that may drive for numerous applications in various research fields, especially in digital applications. Denoising of an image is the task of rectifying the images by eliminating the unwanted signals and the data from the image. Various noise reduction techniques are came into existence to different characteristics of the image to be denoised. The primary characteristic is the noise strength. Based on the type of application we can select different denoising algorithm. The basic noises that occur in the images are the additive and multiplicative noise which may include Gaussian noise, Salt and Pepper noise, Speckle noise and Brownian noise. Images exhibit different features and every feature exhibit noise and it transmit through the noisy channel. The amount of noise that present in the images can be estimated based on the signal to noise ratio (SNR). Different techniques can be implemented based on the different type of noise.

The main goal of the image denoising is to remove noise along with the edge preserving and also fine details of the image should not be disturbed. The fine details in an image is difficult to be differentiated from noise and this leads to denoising artifacts such as ringing, blur, staircase effect, checkerboard effect. The requisite for effectual image denoising methods has augmented with the greater production of digital images. In every application a development is made in order to extend the range of image.

II. Literature Survey

Hasegawa, M., et al. [7] provided a new method for reducing the difficulties in image reconstruction by determining the image based on the non harmonic analysis methodology. This NHA method can capture the accurate spectra without depending on the window and frequency resolution is low by comparing with that of DFT. The texture parts of the image are displayed in a serial manner depending upon the captured information. If any areas are missing in the spectrum then they are recovered by applying the cost function for 2D NHA. But this method is complex and it consumes more time.

Yoshizawa, T., et al. [5] proposed a method for reduction of noise in the periodic signals by using the high resolution frequency evaluation. The proposed analysis is initiated in order to decrease the troubles in frequency versions of the image. In the proposed machine, non harmonic analysis was applied which includes high frequency resolution which includes the partial strain of body period to the noise discount problem. This method is considered as an alternative pre processing approach to DFT to reduce noise. But the computation and time complexity becomes high.

Marc Lebrun [4] presented an open-source execution of BM3D which is a present denoising technique based on the fact that an image has a locally sparse representation in transform domain. This sparsity is increased by clustering similar 2D image patches into 3D clusters. Despite excellent results this method has several drawbacks those are more complexity, less flexibility, and slower than basic methods. Visually the method often flattens out micro-textured zones and therefore may give poor visual results, in particular for skin textures.

Fei Xu., et al. [17] proposed hyper spectral images (HSIs) denoising based on low-rank matrix factorization, in which the associated robust principal component analysis is resolved low rank matrix factorization component. This method requires only an upper bound of the rank of the underlying low rank matrix rather than the precise value. This method has advantage over the other compared methods in removing the mixed noise effectively and efficiently.

Xiong, R., et al. [10] proposed a denoising algorithm based on the signal modeling and regularization. In this approach the author considered the non stationary signals and different transforms in order to apply the adaptive techniques. In these techniques the distribution model is implemented on the image by considering a patch in that image. From this patches variance metrics are extracted by applying the non local similarity technique and these features are used for clustering the likelihood patches. The segmentation is done based on the soft thresholding method including with the laplacian approximation of the distribution of same patch coefficients.

Xiao, Y., et al. [6] verified that the l1-l0 minimization method for recovering of signals which are applied with Gaussian and image noise. In this method, l1 is considered as the impulse denoising factor and l0 is the used for sparse representation by assuming the patches in the image. The entire procedure is divided into three stages in which outlier components are divided for the first stage; next stage is used to improve the image from the outlier pixels. Finally in the last stage an algorithm is defined to find a solution for the minimization energy function. But the enhancement of the algorithm is based on the different noise detectors.

Ma, H., & Nie, Y. [11] presented an advanced version for image denoising technique. In this method we divide the image into different sub regions like edges, corners, soft regions by calculating the features of the image regions. They also apply the gradient variance for this purpose. In this method by considering the different denoising technique and edge detection techniques and fused them in order to obtain the denoised images with preserved edges. This can be possible by denoising the images and acquiring the edges using different techniques.

Zhang, J., & Hirakawa, K. [9] provided a noise technique based on the Poisson noise occurred due to sensor noise. In this method mainly image sensor noise is considered with another noise models from different noise. In this method it is also introduced to find correction in the mismatch of the behavior. In this method the denoising technique is used for reducing the denoising drawbacks such as reduction in the edges and texture. But the complexity of the proposed method is twice that of the conventional Poisson image denoising techniques.

Yang, S., et al. [8] presented denoising method to reduce the image noise. In this system, the same properties of the structure and early sparse data of image patches were exploited. Along with this a noise reduction technique such as regularization process through dictionary learning algorithm. The variables are optimized by considering the multiple variables optimization issue. But this method also provides high computational complexity.

III. Proposed Methodology

In this part, the proposed denoising methods were discussed in a brief manner. DCT and DFT are the two techniques from which the image can be analyzed and these methods produces side lobes since the period values of the window used are not integers. Hence we cannot differentiate the sidelobes and noise from the amplitude of these spectrums. Hence the reduction of side lobes should be considered in order to acquiring the denoised image. Hence, the technique is necessary for resolving the analysis of side-lobe suppression issue. Therefore, NHA is mostly suited for thresholding. Our method, Mask NHA is presented in order to reduce the drawbacks that occur due to previous denoising techniques. The Mask NHA algorithm is presented below:

3.1. 2D NHA

In fact, the Mask NHA is obtained based on the two dimensional NHA which is rather obtained from the 2D DFT in spatial domain as follows:

$$Y(k,l) = \sum_{k=0}^{N-1} \sum_{l=0}^{M-1} I(m_1 - m_2) e^{-j2\pi(\frac{km_1}{N} + \frac{lm_2}{M})} \quad (1)$$

In equation (1), Y represents the image data; M and N are the sizes of the data. The full periodic signal in an M×N analysis window is considered by the short Fourier transform. In this technique the frequency period is adjusted as an integer value as $\frac{K}{N}$ since, if this period is not an integer value then side lobes may exist. Hence the Fourier coefficients are obtained using the wave fitting of sinusoidal waveform using the 2D sinusoidal model is obtained in the below equation:

$$I(m_1, m_2) = \hat{A} cos(2\pi \frac{\hat{f}x}{fx_s} m_1 + \frac{\hat{f}y}{fy_s} m_2 + \hat{\emptyset}) \quad (2)$$

In equation (2), $\hat{A}$ refers the magnitude of the sinusoidal model, $\hat{f}x$ and $\hat{f}y$ are the spatial frequencies, and $\hat{\emptyset}$ is the phase parameter of the model. The sampling frequencies are signified as fx_s and fy_s again in that each of them are represented as $fx_s = \frac{1}{\delta x}$ and $fy_s = \frac{1}{\delta y}$ respectively where x and y are considered as the image representation in two dimensional. By this method the mean square error is reduced in between the input image and finally extracted noise free image. This can be obtained using the steepest descent algorithm. Then obtained quality metrics are represented using below equation:

$$S(\hat{A}, \widehat{f_x}, \hat{f_y}, \hat{\emptyset}) = \frac{1}{M_1 M_2} \sum_{m_1=0}^{M_1-1} \sum_{m_2=0}^{M_2-1} \{I(m_1, m_2) - \hat{I}(m_1, m_2)\}^2 \quad (3)$$

The equation (3) is solved by calculating the 2D dct coefficients as the first values. But the resolution of the image by considering the dct coefficients is depend on the size of the window. But if we eliminate the side lobes the information of the original data may be loss. Hence, using our proposed method we suppress the sidelobes instead of eliminating them and in turn the frequency resolution also increases.

3.2. Mask NHA

A patch is considered in the unit size and it is used for denoising the image by transferring the image from one domain to another. The smoothing and denoising of the image is based on the dimensions of the patch. The edge is converted into the sinc function by utilizing the DFT. By considering the threshold for noise removal it may reduce the sinc function which results to deduction in the edges of the image. If we restored the image from the above process the image may be obtained with ringing artifacts. The edge data of the image is also vanished due to suppression of the side lobes. A window is required for masking operation in a way to minimize the non stationarity of the signal. This mask can be obtained based on the segmentation results.

The segmentation process is done by separating the image filled with noise into two regions such as edge region and texture region. Again the texture region which contains the texture features of the image is divided into more other regions by grouping the regions with similar features. Hence, the target region is denoted as Ω, and the remaining region is denoted as $\hat{\Omega}$. The weighting factor $w(m_1, m_2)$ is determined by considering the binary information from these two regions Ω and $\hat{\Omega}$. The generated weighting factor is called as the masking matrix. If the outer region is represented in the image then the weighting factor is 0 and if it is the target region then the weighting factor is represented with 1. The cost function is given as follows,

$$S(\hat{A}, \widehat{f_x}, \hat{f_y}, \hat{\emptyset}) = \frac{1}{M_1 M_2} \sum_{m_1=0}^{M_1-1} \sum_{m_2=0}^{M_2-1} w(m_1, m_2) \times \{I(m_1, m_2) - \hat{I}(m_1, m_2)\}^2 \quad (4)$$

The cost function is used for extracting the spectrum from Ω excluding $\hat{\Omega}$. While the primary values are assigned by the Fast Fourier Transform (FFT), Ω must be given the temporary value.

3.3. Edge-Preserving Segmentation

Segmentation results to loss in the edge regions. Hence there is a need to achieve the image with edges after segmentation in order to achieve the image with structural similarity. Hence during segmentation we divide the regions into clusters or groups without edges in order to eliminate the artifacts. Segmentation in this context needs to extract the boundary regions which may leads to difficulty and may also provide errors. Therefore fuzzy boundaries are used to determine the edges. In this process there is a chance of occurrence of the boundary distortion, so we apply texture boundaries for reducing the above drawback.

Before edge detection the images are to be smoothed by using different smoothing filters. Here the edge detection is based on the canny edge detection and smoothing is done based on the bilateral filter [13]. This bilateral filter acts as an edge preserving filter since it consists of the pixel values which are difference between the luminance values of the considered pixel and adjacent pixels. The bilateral filtering is denoted as,

$$L(x) = \frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} I(\varphi)w(\varphi,x)d\varphi}{\int_{-\infty}^{\infty} w(\varphi,x)d\varphi} \qquad (5)$$

$$w(\varphi,x) = exp\left(\frac{-(\varphi-x)^2}{2{\sigma_d}^2}\right) exp\left(\frac{-(I(\varphi)-I(x))^2}{2{\sigma_r}^2}\right) \qquad (6)$$

In equation (5), we consider input image as I and output image as L, the spatial variables are x and $\boldsymbol{\varphi}$ and $\boldsymbol{\sigma_r}$ and $\boldsymbol{\sigma_d}$ are considered as standard deviation of the edge sensibility and intensity of filter. To subdivision the images we can relate the region growing and merging algorithms. Once the edges are detected, then the edge segmentation is performed based on the mentioned algorithms.

Region growing is defined as the technique for iteratively expanding the initial region and the region merging is the process of combining the over-segmented results.An additional segmentation algorithm is the mean shift algorithm implemented by means of the thickness of the local points in the feature space [14]. To produce the segmented image a mean shift algorithm is build by allowing for the image features,

$$\widehat{l_{h,K(x)}} = \frac{c_{k,d}}{nh^d}\sum_{n=1}^{n} k\left(\left\|\frac{x-x_i}{h}\right\|^2\right) \qquad (7)$$

In equation (7), x refers the variable vector, x_i are sample vectors, k is the kernel function, h is the band parameter, and $c_{k,d}$ represents the normalization constant. The surfaces which are curved are extracted using the local maxima of the region obtained from the iteration process and using this we obtain the kernel density function. Hence this function for $k(x)$ can be represented as

$$q(x) = -k'(x) \qquad (8)$$

Therefore, the recursion for convergence to the local maximum is represented as follows:

$$r_{j+1} = \frac{\sum_{i=1}^{n} x_i q\left(\left\|\frac{r_j-x_i}{h}\right\|^2\right)}{q\left(\left\|\frac{r_j-x_i}{h}\right\|^2\right)}, j = 1,2, \ldots . \qquad (9)$$

Mean shift segmentation is obtained by clustering the local maxima region obtained through the relation between each pixels at any point $r_{i,1} = x_i$ and its neighboring points.

IV. Results and Discussions

In this section, the results and metric values are examined by using Mask NHA in order to compare the proposed method with BM3D and low rank factorization techniques. The images used for implementation of the proposed algorithm are taken from the Laboratory for image video Engineering (LIVE) image dataset.

Figure 1(a). Target image

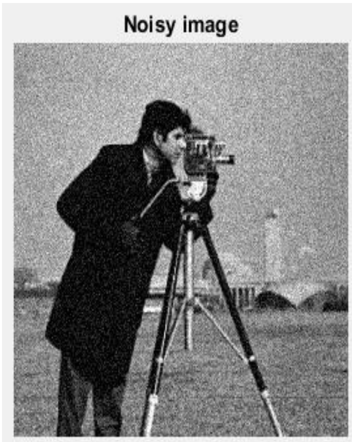

Figure 1(b). Noisy image

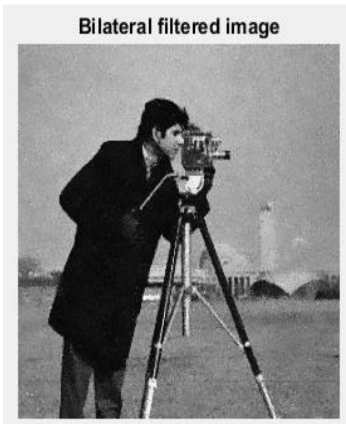

Figure 1(c). Bilateral filtered image

The target image cameraman is represented in figure 1(a). The target images were assumed to be noisy free images. Then we apply awgn to them in order to acquire the noisy images. The noisy image thus produced is represented in figure 1(b). The parameters vary according to the nature of the input signal. So, these parameters are selected from the inputs. However, we used constant parameters throughout this experiment except in the spectral thresholding process. Each parameter was calibrated for the Cameraman image.
We aimed to increase the denoising quality of an image through preprocessing in this paper. As a pre-processing technique we applied the bilateral filter for the noisy image. The filtered image is depicted in figure1(c). The bilateral filter is a non-linear method, with this method an image can be blurred, preserving strong edges. Blurring is one of the simplest ways to smooth an image. Each pixel value from output image is a weighted sum of its neighbors in the input image.

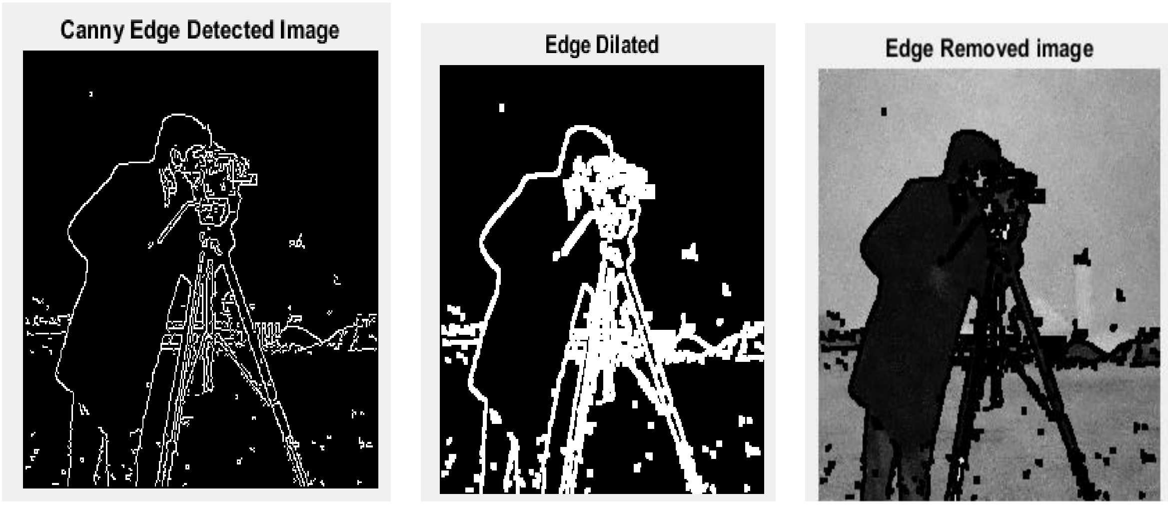

Figure 2 (a). Edge detected image **Figure 2(b). Edge dilated image** **Figure 2 (c). Edge removed image**

For detection of edges an edge detection technique is implemented by using the canny edge detection method. The results obtained using the above algorithm is shown in figure 2(a). In order to improve the detection we apply bilateral filter. Then the edge dilation image is represented in figure 2(b). To define the regions of edges we used the dilation method. To minimize the influence of image non-stationarity, it is necessary to exclude edges and different textures from the analysis window. The removal of edges is shown in figure 2(c). Therefore, the image given as input in the analysis window needs to be masked. The masking area is obtained from image segmentation results.

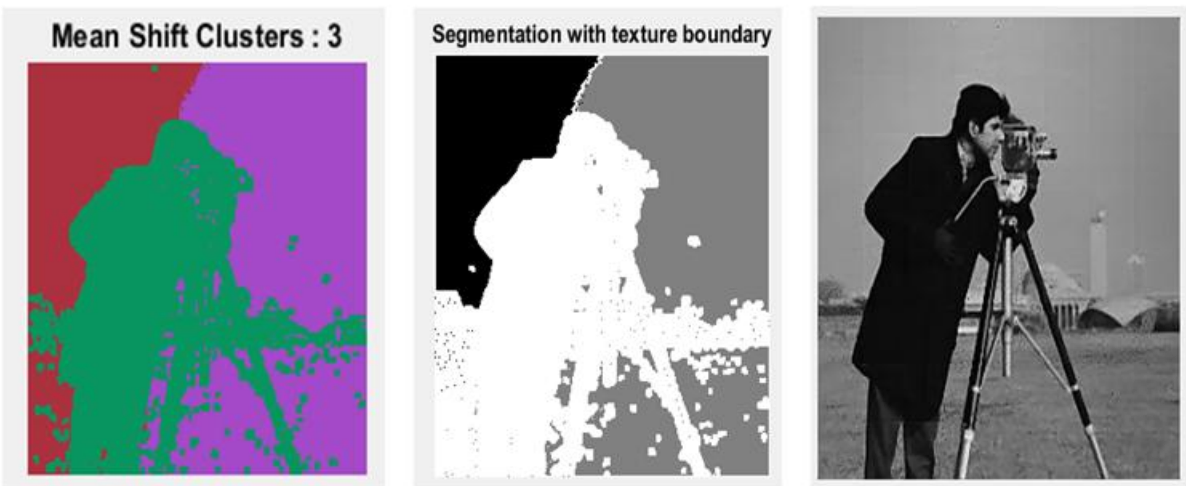

Figure 3(a): Mean shift segmentation **Figure 3(b): Texture boundary Segmentation** **Figure 3(c): Denoised image using Mask-NHA**

Two well-known strategies for image segmentation are based on the region of the target object. They are region growing and merging. In these two region growing stands for the increasing the regional part from initial to final by considering the iteration process and region merging is a method that combines the over-segmented results. These methods cannot be used without prior knowledge of the image in question. We thus used the mean shift-based image segmentation. This segmentation algorithm is implemented using the features extracted using the local maxima region. Moreover, mean shift does not require information regarding the number of segments. Segmentation of the image using the mean shift is executed by considering the relationship between the present pixels and the neighboring pixels in the image. The segmented image using mean-shift algorithm is represented in figure 3(a).Boundary distortion due to segmentation is reduced by defining the texture boundaries. So, that we defined the texture boundary which shown in the fig. 3(b).

After image segmentation the image denoising is implemented in frequency domain by transferring the image and considers a block generally called as patch. The image smoothing depends on the consideration of the size of the patch. Then the patches are extracted from the layers of interest. Then we used the Mask-NHA to calculate the spectra. Finally, the denoised image represented in figure 3(c) can be restored by combining all the layers which obtained by the process of thresholding.

Table 1: Comparison of BM3D and Low Rank Factorization with Mask-NHA method for cameramen

	PSNR(dB)			MAE			SSIM		
	BM3D	LRF	Mask-NHA	BM3D	LRF	Mask-NHA	BM3D	LRF	Mask-NHA
σ= 5	40.97	41.2380	42.0226	2.23	1.6045	1.6033	0.970	0.9699	0.9702
σ= 10	36.15	40.6213	41.9099	3.38	1.7154	1.6574	0.942	0.9699	0.9702
σ= 15	33.29	39.5627	40.3452	4.26	1.8997	1.7811	0.913	0.9695	0.9697
σ= 20	31.50	38.8209	39.8281	5.12	2.0252	1.9231	0.886	0.9693	0.9698
σ= 25	30.41	38.4413	39.3706	5.83	2.0744	2.0517	0.862	0.9690	0.9695
σ= 30	29.54	37.2925	38.8172	6.55	2.2873	2.1923	0.841	0.9685	0.9688

The proposed Mask-NHA denoising method is compared with the BM3D and Low Rank factorization in table-1 in terms of PSNR, MAE and SSIM. The quality metric values are calculated at different noise intensity values. When compared with BM3D and Low Rank factorization the proposed method is effective between $\sigma = 5$ and $\sigma = 30$ in terms of the PSNR. With regard to noise intensity, the proposed method is robust in terms of MAE in between $\sigma = 5$ and $\sigma = 30$. We used SSIM as an objective evaluation indicator and found that our proposed method outperforms than the other method. The experimental results have proven that the proposed approach is better when compared with the recent methods. The proposed approach applied on different images for diverse applications and it has produced flawless results compared to all other techniques of image denoising. Finally, this indicates that denoising can be facilitated by image segmentation and edge preservation.

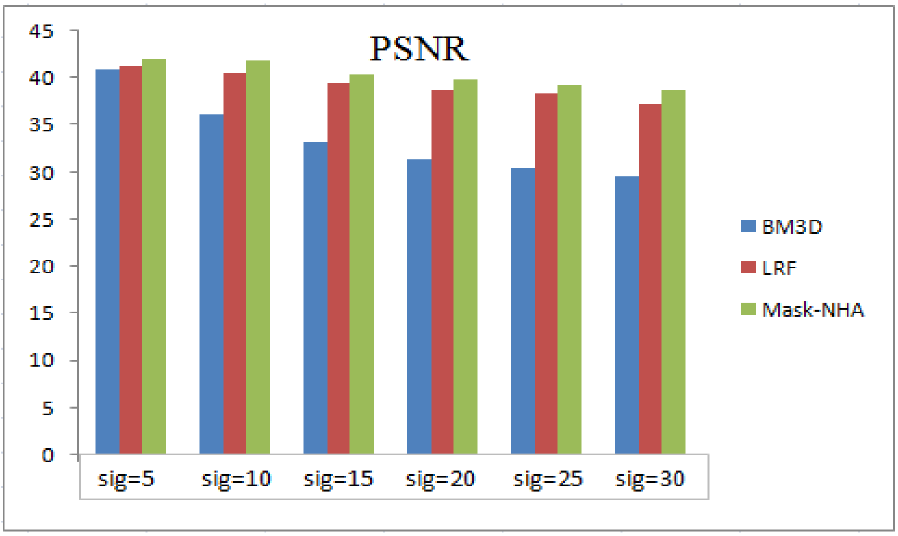

Figure 4(a): Comparison of PSNR for BM3D, LRF and Mask-NHA

Comparison of PSNR for BM3D, LRF and Mask-NHA was represented in figure 4(a) in the form of bar graphs. Here we noticed that Mask-NHA gives better PSNR compared the two other techniques.

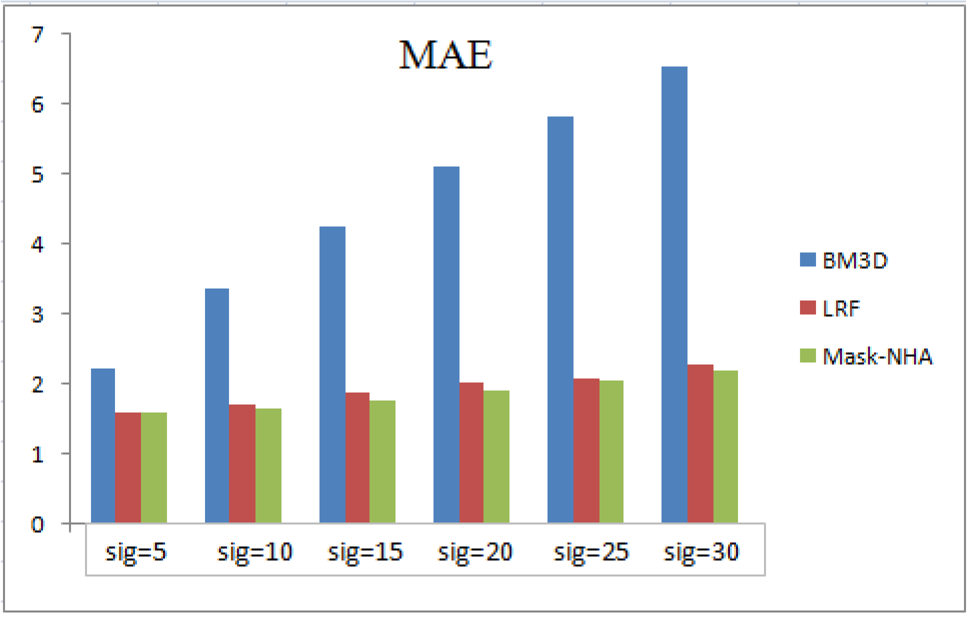

Figure 4(b): Comparison of MAE for BM3D, LRF and Mask-NHA

Comparison of MAE for BM3D, LRF and Mask-NHA was depicted in figure 4(b) in the form of bar graphs. Here we noticed that Mask-NHA gives better MAE compared the two other techniques.

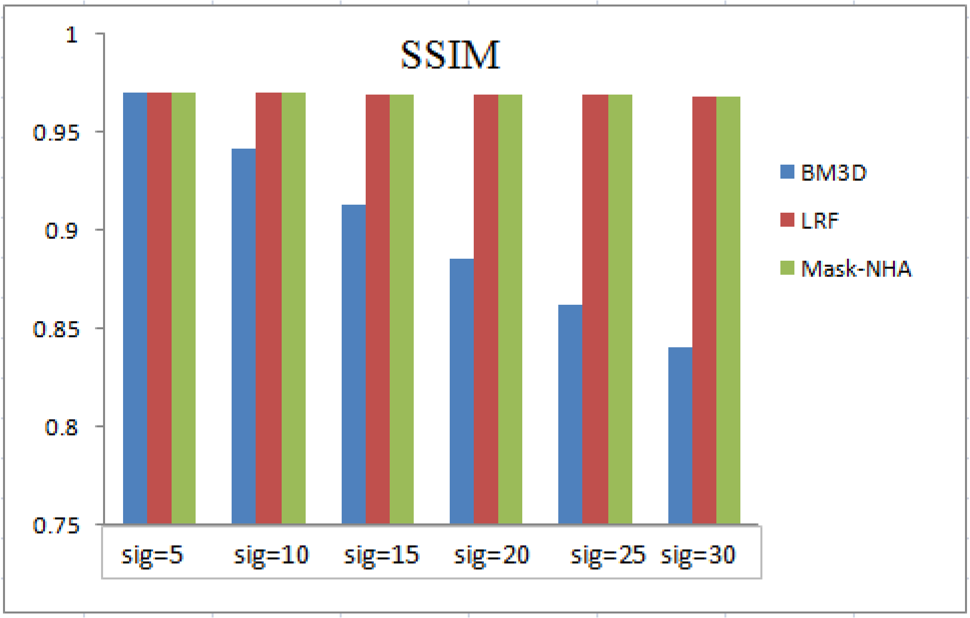

Figure 4(c): Comparison of SSIM for BM3D, LRF and Mask-NHA

Comparison of SSIM for BM3D, LRF and Mask-NHA was depicted in figure 4(c) in the form of bar graphs. Here we noticed that Mask-NHA is equal with the other two techniques at sigma=5and the LRF, Mask-NHA are almost equal for the other sigma values.

V. Conclusion

Denoising of images using different technique is a complexity task in all the image processing applications. Hence we go for frequency analysis which is a new approach for image denoising process. Our method eliminates noise with the help of the denoising technique and at the same time preserves the edges. For edge preservation we implement the canny edge detection method and mean shifting algorithm for segmentation in which different parameters are estimated. During the edge detection in the image a threshold based approach is implemented. Finally, the obtained results are compared with the state of art methods and it is proved that our method provides high PSNR and has more structural similarity in the denoised image.

References

[1]. Rajni, R., & Anutam, A. (2014). Image denoising techniques-An overview. International Journal of Computer Applications, 86(16), 13-17.

[2]. Pathak, M., & Singh, S. (2014). Comparative analysis of image denoising techniques. International Journal of Computer Science & Engineering Technology, 1(5), 160-167.

[3]. Singh, R., Singh, P., & Parveen, F. (2015). Brief review on image denoising techniques. International Journal of Science, Technology & Management, 4(1), 336-344.

[4]. Marc Lebrun (2012). An Analysis and Implementation of the BM3D Image Denoising Method.IPOL journal image processing online,2012(2).

[5]. Yoshizawa, T., Hirobayashi, S., & Misawa, T. (2011). Noise reduction for periodic signals using high-resolution frequency analysis. EURASIP Journal on Audio, Speech, and Music Processing, 2011(1), 5.

[6]. Xiao, Y., Zeng, T., Yu, J., & Ng, M. K. (2011). Restoration of images corrupted by mixed Gaussian-impulse noise via l 1–l 0 minimization. Pattern Recognition, 44(8), 1708-1720.

[7]. Hasegawa, M., Kako, T., Hirobayashi, S., Misawa, T., Yoshizawa, T., & Inazumi, Y. (2013). Image in painting on the basis of spectral structure from 2-D nonharmonic analysis. IEEE Transactions on Image Processing, 22(8), 3008-3017.

[8]. Yang, S., Zhao, L., Wang, M., Zhang, Y., & Jiao, L. (2013). Dictionary learning and similarity regularization based image noise reduction. Journal of Visual Communication and Image Representation, 24(2), 181-186.

[9]. Zhang, J., & Hirakawa, K. (2017). Improved Denoising via Poisson Mixture Modeling of Image Sensor Noise. IEEE Transactions on Image Processing, 26(4), 1565-1578.

[10]. Xiong, R., Liu, H., Zhang, X., Zhang, J., Ma, S., Wu, F., & Gao, W. (2016). Image Denoising via Band wise Adaptive Modeling and Regularization Exploiting Nonlocal Similarity. IEEE Transactions on Image Processing, 25(12), 5793-5805.

[11]. Ma, H., & Nie, Y. (2016). An edge fusion scheme for image denoising based on anisotropic diffusion models. Journal of Visual Communication and Image Representation, 40, 406-417.

[12]. Fan, F., Ma, Y., Li, C., Mei, X., Huang, J., & Ma, J. (2017). Hyper spectral image devoicing with super pixel segmentation and low rank representation. Information Sciences, 397, 48-68.

[13]. Vandana, M., & Srinivas, R. (2011). An optimized algorithm for ringing region detection in compressed images. International Journal of Modern Engineering Research (IJMER), 1(2), 261-269.

[14]. Ghassabeh, Y. A. (2015). A sufficient condition for the convergence of the mean shift algorithm with Gaussian kernel. Journal of Multivariate Analysis, 135, 1-10.

[15]. Awad, W. A., & Elseuofi, S. M. (2011). Machine learning methods for spam e-mail classification. International Journal of Computer Science & information Technology (IJCSIT), 3(1), 173-184.

[16]. Yang, X. S. (2010). Firefly algorithm, Levy flights and global optimization. In Research and development in intelligent systems XXVI (pp. 209-218). Springer London.

[17]. Fei Xu, Yongyong Chen, Chong Peng (2017). Denoising of Hyper spectral Image Using Low-Rank Matrix Factorization, IEEE Geoscience and Remote Sensing Letters .

[18]. K.M.Hemambaran, Dr.S.A.K.Jilani (2018). HRFA Noise Removal and Segmentation: A Review, International Journal of Emerging Technologies and Innovative research, 5(7), 464-468.

K.M.Hemambaran. " HRFA Based Image Denoising With Edge Preserve Segmentation." IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) 13.6 (2018): 27-34.