Improved Approach For Image Denoising Using Multi-Resolution Analysis and Adaptive Median Filtering with SOM Algorithm

Anil kushwah[1], Anuj Bhargava[2], Prasant Badal[3]
Department of ECE
[1]SRCEM College Gwalior, India
[2,3] Professor, SRCEM College Gwalior, India

Abstract-*in denoising issues, signal and noise can be divided in the process and hence reduction of noise becomes easier. In this proposed present that when a nonlinear median filter (MF) is used in multiresolution environment, once in full resolution and then with half resolution, denoising becomes more perfect. This method is a non linear processing and is found to be beneficial in decreasing now not simplest impulse noise but also GN and SN. Further, it's also proposed that utilize of a nonlinear adaptive median filter creates extra satisfying picture with enhanced denoising. It is also shown that the proposed method is useful for color image denoising too. This paper presents a new approach of self organizing migration algorithm (SOMA) with adaptive median filter (AMF) for restoring the original image with picture quality. In this study, apply this algorithm on different window size and varying noise density. In the SOM approach, find the optimal solution (type of wavelet, level of decomposition and varied threshold value) for denoising. SOMA obtains better quality with the help of varying threshold on the basis of picture pixels. For noise free image evaluation using various parameters for example Peak Signal Noise Ratio (PSNR) and Structural Similarity Matrix (SSIM). It is shown that the improved method gives a high degree of noise removal while preserving the edges and other information in the image. The proposed threshold computation is based on average of image pixel values on window size which improves the PSNR of the system as compared to previous DWT-ADM and other median based filters.*

Keywords-SOMA; PSNR; NLM; SSIM; Gaussian Noise; Impulse Noise; Speckle Noise.

I. INTRODUCTION

Image denoising (ID) is a classical and successful studies topic in Image processing. (IP) [1]. The Digital images (DI) play a critical function each in every day existence application which include satellite television, pc tomography as well as in areas of studies and era including geographical facts structures and astronomy. In truth, a picture is mixed with certain quantity of noise which decreases visual quality of picture. Therefore, removal of noise in an image is a very common problem in recent research in IP.

An image receives corrupted with noise throughout gaining or at broadcast because of channel errors or in storage media due to faulty hardware. Removing noise from the noisy picture continues to be a challenging hassle for researchers.

Noise may be classified as substitutive noise (impulsive noise: e.g., Salt and pepper noise (SPN), random valued impulse noise, and plenty of others.), additive noise (e.g., additive white GN) and multiplicative noise (e.g. SN). However, in this paper the investigation has been constrained to additive white GN. In popular, the goal of any noise removal scheme is to suppress noise in addition to keep info and edges of picture as a great deal as feasible. [2]

Gaussian Noise (GN)

The standard model of amplifier noise is additive, Gaussian, impartial at every pixel and independent of the sign intensity.

Speckle Noise (SN)

It is a multiplicative noise. These sorts of noise take place in nearly all consistent imaging structures inclusive of laser, acoustics and SAR (Synthetic Aperture Radar) imagery. The supply of this noise is attributed to random interfering a few of the coherent returns.

Discrete Wavelet Transform (DWT)

DWT-founded ways allow good spatial localization and have multi resolution facets, which are the alike to the social image scheme. In a similar way this procedure displays robustness to low-pass and center cleaning. The turn out to be is situated on waves, called wavelets, of varying frequency and confined duration. It supplies each frequency and spatial description of an image. The wavelet transform (WT) decomposes the image into three spatial instructional materials, i.e. vertical, horizontal and diagonal. It decomposes the image into special frequency stages corresponding to low frequency (LF), middle frequency and high frequency (HF). Magnitude of DWT coefficients is excessive in the lowest bands (LL) at each stage of decomposition and is least for different excessive bands. [3]

Median Filter (MF)

The MF is a non-linear smoothing method that decreases the blurring of edges; right here the idea is to replace the contemporary factor inside the image by way of the median of the brightness in its neighborhood. The median of the brightness within the community isn't affected by character noise spikes. The MF removes impulse noise efficiently. Since MF does not blur edges much, it is able to be carried out iteratively. One of the main issues with the MF is that it's miles notably expensive and is hard to compute. It is essential to sort all the values in the neighborhood into numerical in order to find out the median value which is relatively slow.[4]

Adaptive Median Filtering (AMF)

The AMF executes spatial processing to decide which pixels in a picture have been tormented by noise. A pixel this is one-of-a-kind from a majority of its neighbours, as well as being now not structurally aligned with the ones pixels to which its miles comparable, is exact as impulse noise. These noisy pixels are then replaced by means of the median value of the pixels inside the neighbourhood which have handed the noise detection test. [5]

Notations:
Sxy = Processing Window (Size)
Zmin = Minimum Grey Level Value in Sxy
Zmax = Maximum Grey Level Value in Sxy
Zmed = Median of Grey Levels in Sxy
Zxy = Grey Level at Coordinates (x, y)
Smax = Maximum Allowed Size of Sxy

SOMA

SOMA, an evolutionary algorithm, was proposed in 2000 by Zelinka. The method of SOMA is resulting from the social conduct of animals while rummaging for meals. If one of the animals in a pack finds a food source, others follow him to get to the site. Thus the former becomes a leader. A comparable procedure is used by SOMA, where in a population of people (solutions in a search space) is characterized by their position. Based on the fitness (similar to closeness to food), of each individual one of them assumes the position of a leader and others follow the leader by updating their position. [6-7]

II. LITRETURE SURVEY

[8] In denoising problems, signal and noise can be separated in the process and hence elimination of noise becomes easier. It is proposed on this paper that when a nonlinear MF is utilized in multiresolution surroundings, once in complete resolution after which with 1/2 resolution, denoising will become extra best. This technique is a non linear processing and is found to be useful in reducing not only impulse noise but also Gaussian and Speckle noise. Further, it's also proposed that use of a nonlinear AMF produces greater fascinating picture with enhanced denoising.

[9] In this paper, we advise an MF and adaptive wavelet thresholding shrinkage approach for ID. The noisy image is passed through pre-processing MF to remove the noise and two level DWT is applied which is passed through post-processing MF to remove noise. The IDWT is carried out to reconstruct the image. The picture worth is measured in terms of the PSNR and is determined that the proposed scheme obtains higher PSNR as compared to existing method.

[10] Image denoising has been a nicely-studied difficulty for imaging structures, specifically imaging sensors. Despite super progress within the satisfactory of denoising algorithms, chronic challenges continue to be for an extensive elegance of general pictures. In this work, we present a new concept of collection-to-collection similarity. This similarity degree is an effective technique to assess the content similarity for pictures, mainly for part information. The method differs from traditional IP strategies, which rely upon pixel and block similarity.

[11] In this paper, according to the extraordinary function of UV detection picture, a Partial Differential Equation of Adaptive Median Filter (AMF-PDE) algorithm is proposed to process the output image of ultraviolet ICCD camera. The outcomes display that AMF-PDE is able to get better submerged sign and preserve details of UV detection picture correctly.

[12] In this paper, SOM founded procedure is proposed for MRI picture processing. Such pictures are generally corrupted by way of Rician noise generated at some point of the picture formation processing because of the nature of MRI approach. Rician noise is non-additive, signal based, and rather nonlinear, appreciably exceptional from those commonly discussed in pictures. These features make it very difficult to separate the signal from noise. A SOM set of rules is

cautiously carried out to correct MRI IP with the aid of taking the respectable Rician noise function into attention, resulting in a unique method for denosing and segmentation.

[13] In this paper, we present an algorithm to do away with SPN from grayscale pictures. It is a more desirable AMF algorithm which to start with calculates median without thinking about noisy pixels within the processing window. If the noise-free median fee is not to be had within the maximum processing window, the closing processed pixel fee is used because the alternative. Moreover, in severe conditions along with noise corrupted pure black and white photos, a threshold value is used to determine the pixel value. Experimental outcomes show that our algorithm can perform higher than the other nonlinear filters, suppressing noise level extra than 90% while retaining visible great and vital details of the picture.

III. PROPOSE WORK

Proposed Algorithm

1) For any given N X N gray level image or color image which is defined by $f: N \times N \rightarrow I$ where I = [a, b] represents the range of pixel values. Pixel value at location (i, j) is given by f(i, j).
2) Let r X r be size of the filtering window ‘‘W’’, formed by partitioning of an image.
3) Denote I (x) the intensity value of image I at pixel location x and [dmax ,dmin] the dynamic range of I. Dynamic range of image gray levels. For 8-bit images, dmax = 0 and dmin = 255. Impulse noise are as follows:

$$I_{noisy}(x) = \begin{cases} d_x & \text{with probability } r \\ I(X) & \text{with probability } (r-1) \end{cases} \quad (1)$$

Where dx is uniformly distributed in [dmax,dmin]and r determines the level of impulse noise .

4) Suppose y is a noisy image gathered by adding zero mean Gaussian noise and Speckle noise n to noise free image I then it can be said that:

$$y = x + n$$

5) If image is color then convert into Ycbcr format otherwise continue with gray image.
6) Apply 1DWT on input image to split into four sub-bands :LL ,LH, HL, HH and apply AMF on each band of DWT.
7) Consider that the gray or color levels of any pixel value, in any window (wx) of size n Xn are represented by $X_1, X_2, X_3, X_4, \dots\dots\dots\dots X_1$and it becomes $X_{i1} \geq X_{i2} \geq X_{i3} \geq \cdots \dots\dots . X_{in}$ after sorting it in descending or in an ascending order

$$M_X = Median\,(W_X) = \begin{cases} X_{i(n+1)/2;} & n \text{ is odd} \\ \frac{1}{2}\left[X_{i\left(\frac{n}{2}\right)} + X_{i\left(\frac{n}{2}\right)+1}\right]; & n \text{ is even} \end{cases} \quad (2)$$

8) A generalized filtering window ‘‘W’’, is given in Eq. (3), it has rxr matrix. The gray or color level at any pixel (i,j) is represented by X(i,j)

$$w = \begin{bmatrix} x_{1,1} & x_{\left(1,\frac{r+1}{2}\right)} & x_{1,r} \\ x_{\left(\frac{r+1}{2},1\right)} & x_{\left(\frac{r+1}{2},\frac{r+1}{2}\right)} & x_{\left(\frac{r+1}{2},r\right)} \\ x_{r,1} & x_{\left(r,\frac{r+1}{2}\right)} & x_{r,r} \end{bmatrix} \quad (3)$$

9) Average values of a set of samples (data values) always lie in close proximity to the values under consideration. Averages of rows and columns of filtering window are used for threshold computation in proposed method which leads to efficient noise detection. In each filtering window, Z_{min} (minimum threshold) and Z_{max}(maximum threshold) are estimated which are used to abrupt changes detect in pixel values. In order to estimation thresholds, first of all, the elements averages in individual rows (A_v(R)) of filtering window are calculated.

$$A_v(R_r) = \frac{1}{r}\sum_{j=1}^{r} X(r,j) \quad (4)$$

10) This process will result ‘‘r’’ average values corresponding to every row. After that the averages of elements in individual columns (A_v(C)) of filtering window are calculated.

$$A_v(C_r) = \frac{1}{r}\sum_{i=1}^{r} X(i,r) \quad (5)$$

11) This process will also result ‘‘r’’ average values corresponding to every column. These ‘‘2r’’, distinct average values will be used for finding Z_{min} and Z_{max} using following equations:

$$Z_{min} = min\{A_v(R_1), \dots A_v(R_r), A_v(C_1), \dots A_v(C_r)\} \quad (6)$$

$$Z_{max} = max\{A_v(R_1), \dots A_v(R_r), A_v(C_1), \dots A_v(C_r)\} \quad (7)$$

12) Now, the noise corruption at Z_{med} of filtering window is checked by comparing it with Z_{max} and Z_{min}. If Z_{med}P value lies between thresholds computed by Eqs. (6) And (7), then it is considered as noise free otherwise noisy.

$$Z_{med} = \begin{cases} Z_{min} < Z_{med} < Z_{max}; & Noisefree \\ Else; & Noisy \end{cases} \quad (8)$$

If the $Z_{med}$is estimated as noisy, then the noise removal is need to be applied at specific Z_{med}, otherwise it is kept same and filtering window is shifted to the next pixel. At noise elimination stage, simple median (M) of the filtering window has been used to change the gray level of the detected noisy pixel.

13) Reconstruct the matrix using inverse DWT after applying AMF and process to SOMA method.

$$\delta = \min\left(t, \sigma\sqrt{2 \times \log\left(no.of pixels\right)}\right)$$

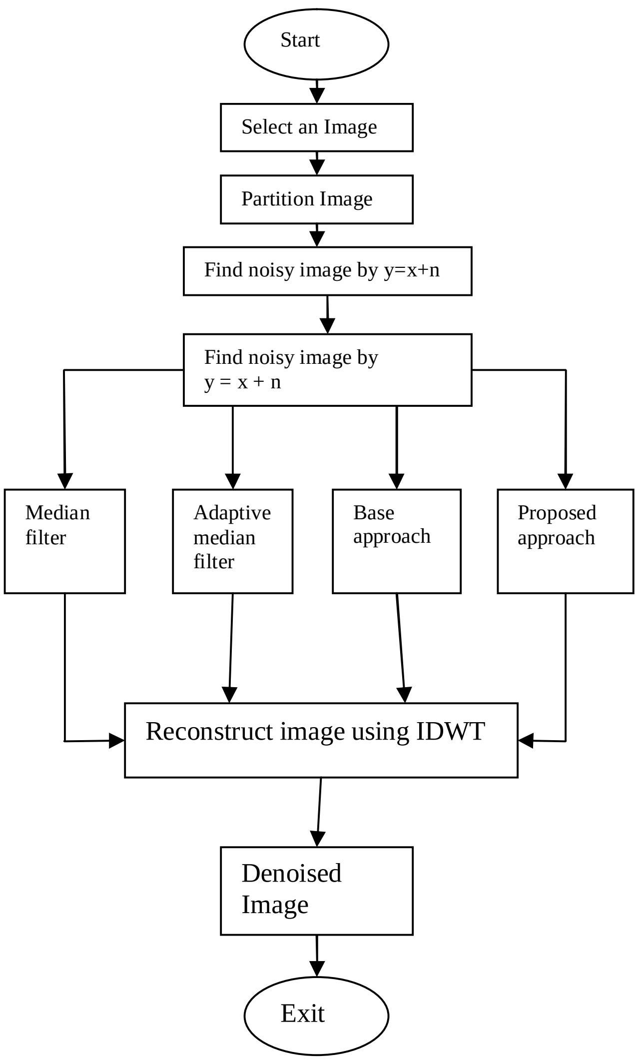


Fig. Proposed flow chart

Where, δ is estimated threshold, t is the threshold which is estimated using AMF method that minimizes Stein's unbiased risk estimator and $\sigma$is the standard deviation of noise, which is estimated as follows (x being wavelet detail coefficients at 4thdecomposition level).

The parameters that govern the convergence and performance SOMA behavior are:

1. Various individuals and their dimension
2. Different iterations (migration loops)
3. Path Length: It governs the position at which a person will stop while following the chief. A value extra than 1 is chosen to heighten exploration.
4. Step Size: It decides the granularity of the course in the direction of the leader.
5. PRT: Pattern created applying this variable directs the

Table 1 Set Variables For Optimization

Variables to be optimized	**Permitted Values**
Types of Wavelet	Daubechies (db4, db6, db8), Symlet (sym4, sym6, sym8, sym10), Coiflet (coif2, coif4)
Decomposition Level	1-4
Threshold	Range is from 0.5σ to 7σ; σ is the estimate of noise variance. (up to 3 threshold values, one for every decomposition level)

Steps worried in primary SOMA (All for one) method are listed beneath

1. Finalize the parameters listed above
2. Initialize the population and compute each individual fitness
3. Select leader (individual with highest fitness)
4. Create PRT vector with the help of equation (9)

$$PRT_{vec}(i) = 1; if rand < PRT for each dimension \quad (9)$$

5. Update the position of individuals using equation (10)

$$x_p^{l+1} \leftarrow x_p^1 + \left(x_{leader}^{l+1} - x_{p,start}^{l+1}\right) \times step\_size \times prtvec$$
(10)

6. Update fitness value and select new leader

Repeat steps 3 to 6 till a termination criterion is satisfied

1) Convert Ycbcr to RGB image to get final denoised image for step5.
2) Calculate PSNR and Mean Square Error (MSE) value of a denoised and original image.

$$\text{MSE}(x) = \frac{1}{N}||x - x^{\wedge}||^2 = \frac{1}{N}\sum_{i=1}^{N}(x - x^{\wedge})^2 \quad (11)$$

Where x is the original image, x^ is denoised image, N is original image size

$$PSNR(x) = \frac{10\ Xlog10\ ((double(m).\hat{}2))}{MSE(x)} \quad (12)$$

Giving original image x and a denoised image x′, N is cover image size, m is the original image maximum value.

3) Structural Similarity Matrix (SSIM)- It is used for calculating similarity content between input image and denoised image.

$$SSIM = \frac{(2\mu_x\mu_y - c_1)(2\sigma_{xy} - c_2)}{(\mu_x^2 - \mu_y^2 - c_1)(\sigma_x^2 - \sigma_y^2 - c_2)}$$

where $\mu_x$is the normal of x, $\mu_y$is the average of y, σ_{xy} is thecovariance of x and y, c_1= $(K_1L)^2$, c_2= $(K_2L)^2$,K_1= 0.01 and K_2= 0.03by default and L is the dynamic range of pixel values.

IV. RESULT ANALYSIS

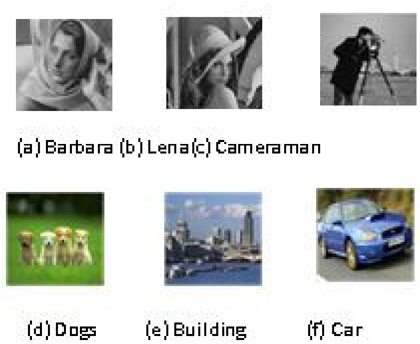


Fig 1 Original grayscale and Color test images of 8-bit per pixel.

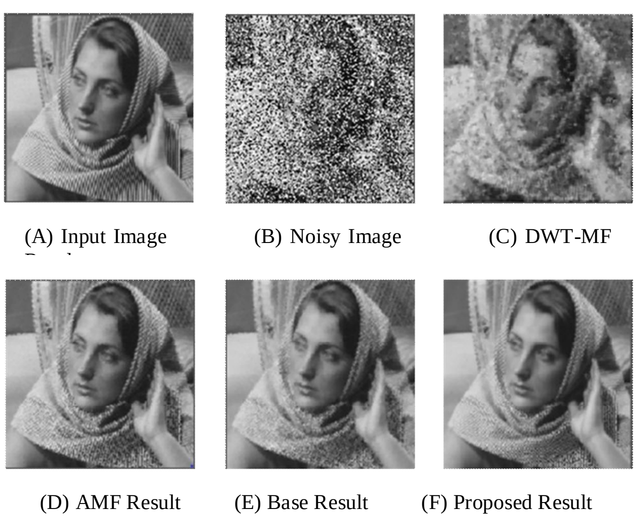


Fig 2 Image (a) Result on Impulse Noise with 40% noise density

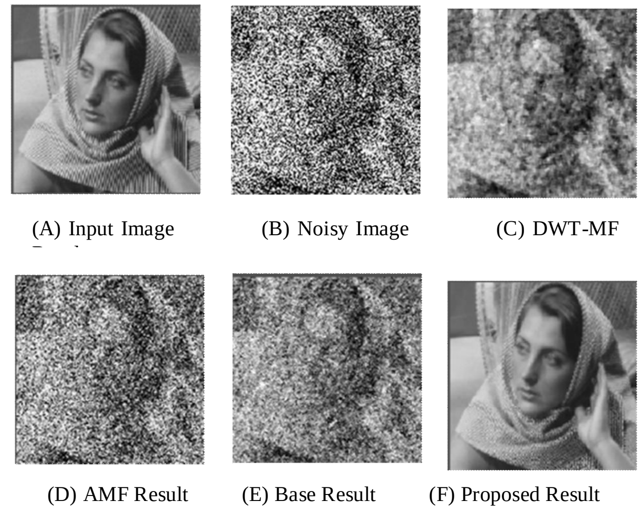


Fig 3 Image (a) Result on Gaussian Noise with 30% noise density

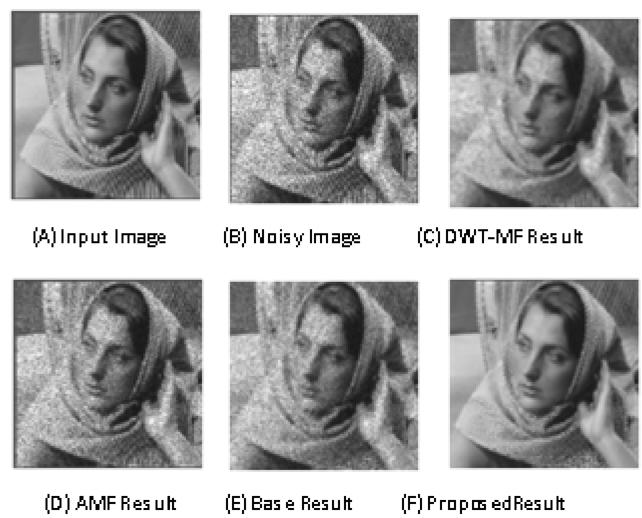


Fig 4 Image (a) Result on Speckle Noise (standard)

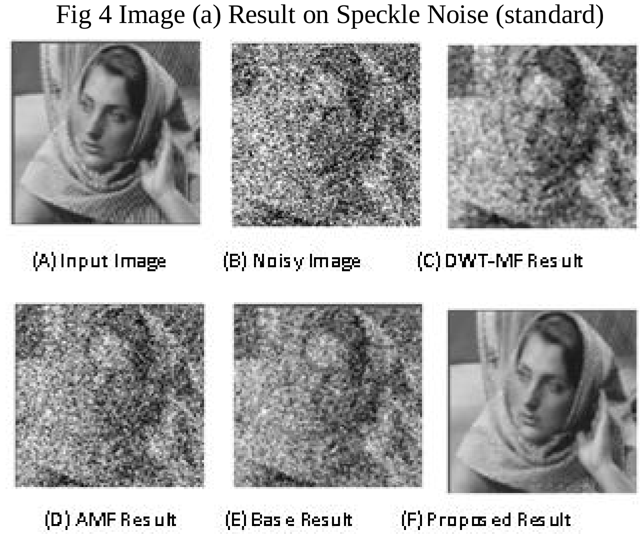
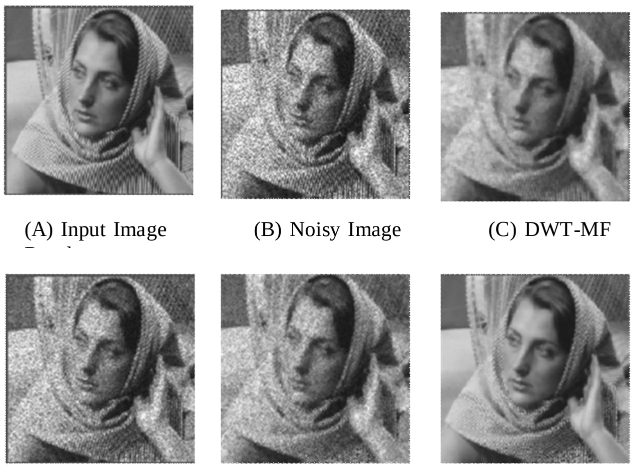


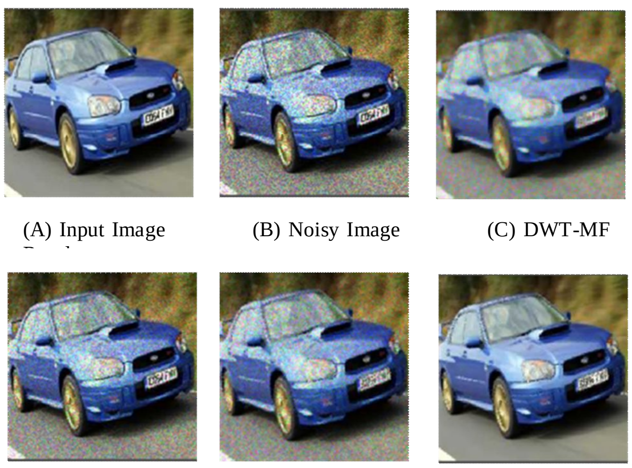
Fig 5 Image (a) Result on Gaussian Noise with 30% noise density



(A) Input Image (B) Noisy Image (C) DWT-MF

(D) AMF Result (E) Base Result (F) Proposed Result

Fig 6 Image (a) Result on Speckle Noise (standard)



(A) Input Image (B) Noisy Image (C) DWT-MF

(D) AMF Result (E) Base Result (F) Proposed Result

Fig 7 Image (f) Result on Speckle Noise (standard)

Table I. PSNR (dB) values of different filters for barbara image degraded by different noise.

Noise	DWT-Median Filter	Adaptive Median Filter	Base Method	Proposed Method
Impulse [40%]	35.1384	25.7221	45.4676	48.1394
Gaussian [30%]	30.4546	11.8181	22.9338	48.0523
Speckle	40.0286	20.9505	40.0263	48.1606

Table II. SSIM values of different filters for barbara image degraded by different noise.

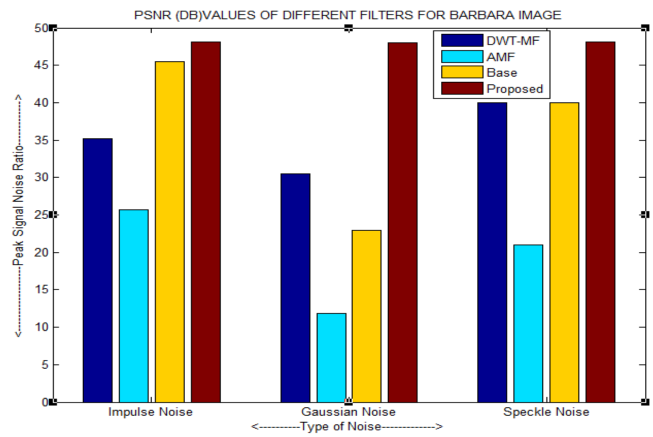
Noise	DWT-Median Filter	Adaptive Median Filter	Base Method	Proposed Method
Impulse [40%]	0.3599	0.8643	0.7679	0.8479
Gaussian [30%]	0.2063	0.0775	0.1006	0.8472
Speckle	0.5083	0.4842	0.4707	0.8475

Table III. PSNR (dB)values of different filters for car image degraded by different noise.

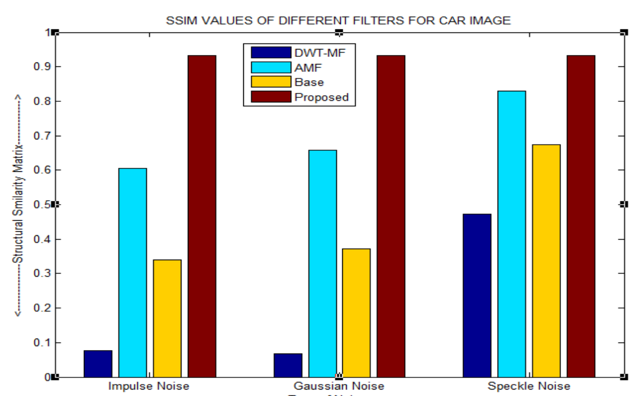
Noise	DWT-Median Filter	Adaptive Median Filter	Base Method	Proposed Method
Impulse [40%]	29.1206	34.6632	31.142	56.2415
Gaussian [30%]	28.543	35.2606	30.9523	56.3004
Speckle	43.5113	55.8486	49.0178	56.2471

Table IV. SSIM values of different filters for car image degraded by different noise.

Noise	DWT-Median Filter	Adaptive Median Filter	Base Method	Proposed Method
Impulse [40%]	0.0765	0.6046	0.3398	0.9323
Gaussian [30%]	0.0681	0.6577	0.3710	0.9321
Speckle	0.4721	0.8284	0.6731	0.9327



Graph.1. PSNR value of different filters for BARBARA image



Graph. 2.SSIM values of different filters for car image

V. CONCLUSION

This research presents and explores a new approach for image denoising using multi-resolution analysis and ADM with SOMA. There are two main process: first is Noise Detection and second is Noise Removal. In noise detection stage, the concept of DWT with averaging based dual threshold method is used which offers high noise detection ability and efficiency. In DWT process, apply SOMA with ADM on each band of DWT. Evaluation outcomes present that the proposed technique of dual threshold is significantly superior various state-of-the-art methods, both quantitatively and visually. It improvises vastly the de-noised image proposed filter quality from 56.2415% for impulse noise on 40% noise density, 56.3004% for Gaussian noise on 30% noise density and 56.2471% for Speckle noise. The simulation results, and associated evaluation criteria represent that our method generates good results, much better than existing work. It helps in noise removal along with preservation of fine details much better than that obtained with other methods.

Hybrid met heuristics techniques may also be used to improve convergence behaviour and quality of solution.

REFERENCES

[1] Jadhav P. B., Dr. Sangale. S. M., “Image Denoising Techniques”. 2015, IJARCSSE

[2] Ms. Jignasa M. Parmar, Ms. S. A. Patil, “Performance Evaluation and Comparison of Modified Denoising Method and the Local Adaptive Wavelet Image Denoising Method”. 978-1-4799-0317-7/13/$31.00©2013 IEEE

[3] Khusboo Agrawal and Rajesh Singh, “ A Survey: Digital Watermarking with its Applications Using Different Methods”. ISSN: 2287-8505 IJDCA 2015 SERSC

[4] Vijayalakshmi. A, Titus.C and Lilly Beaulah.H, “Image Denoising for different noise models by various filters: A Brief Survey”. IJETTCS 2014

[5] Md. Imrul Jubair, Md. Mizanur Rahman, Syed Ashfaqueuddin2, Imtiaz Masud Ziko3, “An Enhanced Decision Based Adaptive Median Filtering Technique to Remove Salt and Pepper Noise in Digital Images”. 987·161284·908·9111/$26.00 � 2011 IEEE

[6] I. Zelinka, J. Lampinen, and L. Nolle, On the theoretical proof of convergence for a class of SOMA search algorithms’. Proceedings of the seventh international MENDEL conference on soft computing, Brno, CZ pp. 103–107, 2001

[7] I. Zelinka, SOMA-Self Organizing Migrating Algorithm, in G. Onwubolu, et al (Eds.), New optimization techniques in engineering, Springer, pp. 167-215, 2004

[8] Malini.S, Moni.R.S, “Image Denoising Using Multiresolution Analysis and Nonlinear Filtering”. 978-1-4673-6994-7/15 $31.00 © 2015 IEEE

[9] Ms.Dhanushree.V , Mr.M.G.srinivasa, “Image De-noising using Median Filter and DWT Adaptive Wavelet Threshold”. (IOSR-JVSP) 2015

[10] Karen Panetta, Long Bao, Sos Agaian, “Sequence-to-Sequence Similarity-Based Filter for Image Denoising”. IEEE. 2015

[11] Zhenzhen Lu, Weiyu Liu, Dahai Han, Min Zhang, “A PDE-based Adaptive Median Filter to Process UV Detection Image Generated by ICCD”. 978-1-4799-3903-9/14/$31.00 ©2014 IEEE

[12] Danchi Jiang, “A SOM algorithm based procedure for MRI image processing under significant Rician noise”. 2013 Australian Control Conference.

[13] Syed Ashfaqueuddin2, Imtiaz Masud Ziko3, “An Enhanced Decision Based Adaptive Median Filtering Technique to Remove Salt and Pepper Noise in Digital Images”. 987·161284·908·9111/$26.00 � 2011 IEEE