Advanced Intelligence System To Remove Salt & Pepper Noise By Modified Median Filter

Sunil Bajpai, Mr. Devendra Singh Kushwaha

Abstract— **Isolating or reducing salt & pepper noise is a vast attractive research in image processing. Removing impulse noise is believed to be very important in the domain of image regression, but it is a certain more challenging area than isolating pure noise. Hence, relatively lesser works have been done in this area. In this paper the Back Propagation ANN based novel approach has been represented for reducing the salt and pepper noise from the high density impulse noisy images, using Advanced Modified Back Propagation Artificial Neural network based Unsymmetric Trimmed Median Filter. The existing MDBUTMF is unable to restore the original image from the noisy images, if noise density is higher than 75%. The performance of the new method is analyzed by using different qualities of metrics, such as Mean Square Error (MSE) and Peak Signal to Noise ratio (PSNR). All simulation results distinctly show that the new method performs better both in qualitative as well quantitative fidelity criteria, when it is compared with MDBUTMF.**

Index Terms—*image processing, salt & pepper noise, median filter, noise density, PSNR, MSE*

I. INTRODUCTION

The Noises moved into digital images during acquisition and/or transmission can be adequately modeled by either Additive Gaussian White Noise (AGWN), impulse noise, or Mixed Gaussian and Impulse Noise (MGIN) [16], [20], [22]. AWGN, which is inadvertently moved to an image during its acquisition stage, can be modeled as adding to each pixel of image a value from a zero-mean Gaussian distribution.

A real filter for removing of AWGN will be able to smoothened pixels within a distinct local region of an image without affecting the sharpness of the image edges of that region. A Gaussian filter, which is almost linear filter, can smoothen noise very efficiently; but it performs it at the price of significant edge blurring. To conquer this problem, some nonlinear filters have been proposed [10, 12, 14, 19], [23] that focus on using local measures of an image to detect the edges and smooth them less than other parts of the image. The most possible type of noise is impulse noise which can also be called as salt & pepper noise [8, 9, 18], Impulse noise, generally caused by transmission errors, can be introduced by randomly replacing a portion of the image pixels with random pixels, while remaining pixels unchanged [17, 21].

The filters specifically developed for AWGN noise removal do not work well on impulse noise, because these filters consider the impulse noise image pixels as edges, and secure them. Different types of filters that aim at removing impulse noise have been introduced, and were summarized by Yildirim et al. as follows: 1) standard median filter, which replaces the center pixel of a filtering window with the median value of all pixels in that window, has decent performance in terms of noise removal, but it also blurs image details thin lines even at a low noise level; 2) modified versions of the median filter, e.g., weighted and center-weighted median filters , [24], [25], which give more weights to certain pixels in the filtering window, gain improved performance in terms of preserving image details at the cost of reduced noise removal capability; 3) approaches based on impulse detectors, which aim at deciding whether the center pixel of the filtering window has been corrupted by noise or not, There are many variants in median filter such as Standard Median Filter (MF), Adaptive Median Filter (AMF), Adaptive Weighted Algorithm (A WA), Switching Median Filter (SMF), Decision Based Algorithm (DBA), Decision Based Asymmetric Trimmed Median Filter (DBUTMF) and Modified BPANN Based Unsymmetric Trimmed Median Filter (MBBUTMF). The drawback of standard Median Filter (MF) [1, 4, 5, 6, 11,13, 15] is that it is effective when the noise density is below 20%, if it is more than 20% the edge as well the image details are lost. Adaptive Median Filter (AMF) [2, 3] gives better performance at low noise densities.

The Modified BPANN Based Unsymmetric Trimmed Median Filter (MBBUTMF) [7] method doesn't provide better visual and quantitative fidelity. The proposed Advanced Modified BPANN Based Asymmetric Trimmed Median Filter (AMBBUTMF) method provides better visual quality and gives reduced Mean Square Error (MSE) and better Peak Signal-to-Noise Ratio (PSNR) values than existing methods.

The rest of the paper is organized as follows. A brief introduction of Modified BPANN Based Unsymmetric Trimmed Median Filter is given Section II. Description about Artificial Neural Network is given in Section III. Section IV describes about the proposed algorithm. The detailed description of the proposed method is illustrated in Section V. Simulation results with different images are presented in Section VI. Finally the paper is concluded with conclusions in Section VII.

II. MODIFIED BPANN BASED UNSYMMETRIC TRIMMED MEDIAN FILTER

The basic concept behind this filter is to reject the noisy pixel from the selected window size of 3x3 with a processing pixel P_Y. If $P_Y = 0$ or 255 then P_Y is a corrupted pixel. If the selected window contains all 0's and 255's, then the pixel P_Y is replaced with the mean element of the window. If the

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selected window does not contains all elements as 0's and 255's, then eliminate 0's and 255's from the selected window and find the median value of the remaining pixel elements.

The P_Y is replaced with the median value. This process is repeated for the entire image. But MBBUTMF suffers from another issue, it assumes that the all the pixel with 0 or 255 value are noisy and the de-noised images should not have any pixels with extreme gray-level values.

III. Artificial Neural Networks

An Artificial Neural Network (ANN) also known as "Neural Network (NN)" is a computational model based on the structure and function of biological neural network. In other words, ANN is computing system which is made up of a number of simple processing elements (the computer equivalent of neurons, Nodes) that are highly interconnected to each other through synaptic weights. The number of nodes, their organization and synaptic weights of these connections determine the output of the network. ANN is an adaptive system that changes its structure/weights based on given set of inputs and target outputs during the training phase it produces final outputs accordingly. ANN is particularly effective for predicting events when the network have a large database of prior examples to draw. The common implementation of ANN has multiple inputs, weight associated with each input, a threshold that determine if the neuron should fire, an activation function that determine the output and mode of operation. The general structure of a neural network has three types of layers that are interconnected: input layer, one or more hidden layers and output layer as shown in Figure 1.

There are some algorithms that can be used to train an ANN such as: Back Propagation, Radial-basis Function, a Support Vector learning, etc. The Back Propagation is the simplest but it has one disadvantage that it can take large number of iterations to converge to the desired solution. In Radial Basis Function (RBF) network the hidden neurons compute radial basis functions of the inputs, which are similar to kernel functions in kernel regression. Speech has popularized kernel regressions, which he calls a General Regression Neural Network (GRNN).

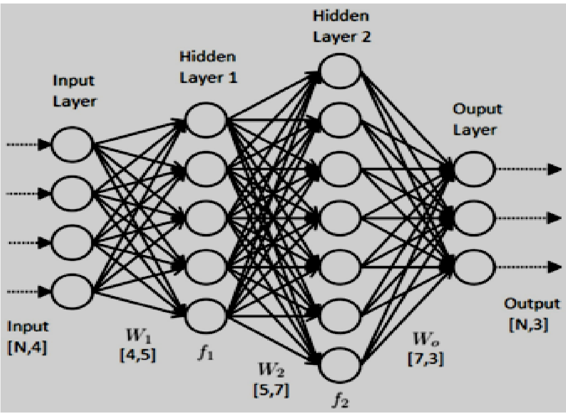


Figure 1: General Structure of Neural Network

IV. PROPOSED ALGORITHM

The proposed BPANN based Advanced Modified BPANN Based Unsymmetric Trimmed Median Filter (AMBBUTMF) first detects the noise from the corrupted image. The processing pixel is verified whether noisy or noise free. If the processing pixel value lies between minimum' l' to maximum '254', then it is a noise free pixel. If the processing pixel value is either 0 or 255, then it is a noisy pixel which is processed by AMBBUTMF. The algorithmic steps in this method are as follows,

FLOWCHART

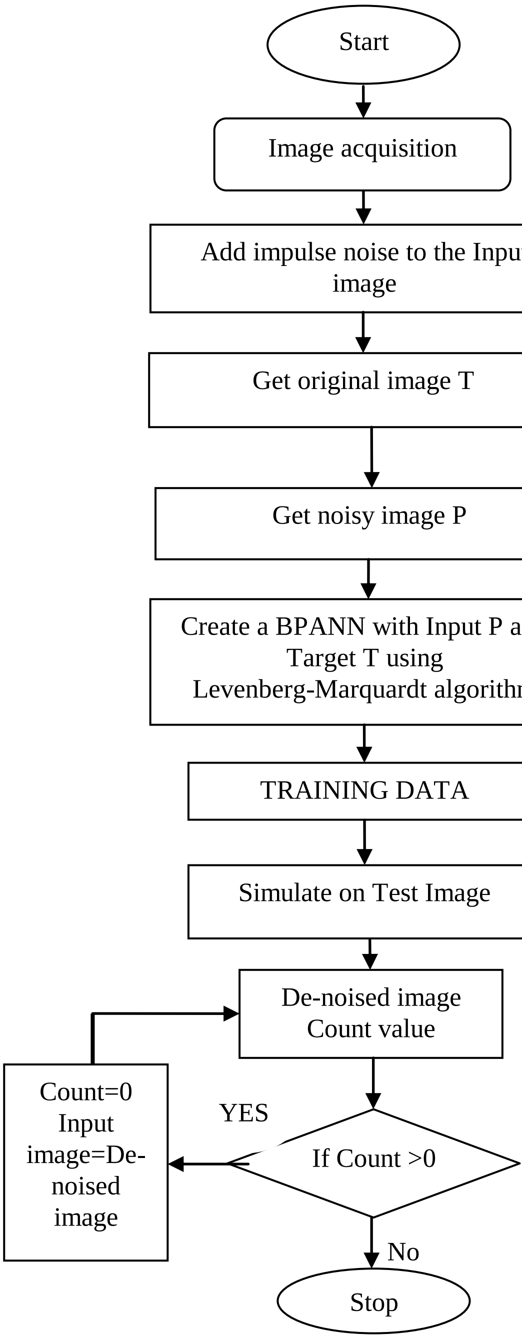


Figure 1: Flowchart of BPANN based MBBUTMF

ALGORITHM STEPS

PHASE 1:

Step 1: Image Acquisition
Step 2: Insert impulse noise to the Input image
Step 3: Get original image T
Step 4: Get noisy image P
Step 5: Create a BPANN with Input P and Target T using Levenberg-Marquardt algorithm
Step 6: TRAIN DATASET
Step 7: Simulate on Test Image

PHASE 2:

Step 1: Insert O's to the First Row, First Column and Last Row, Last Column of the image.
Step 2: Select a window of size 3 x3, and consider the Processing pixel is P_Y in the window.
Step 3: Process the corrupted image:
If the processing pixel value lies between 0< P_Y <255, then it is an uncorrupted pixel and its value is left unchanged.
Step 4: If P_Y =0 or 255, then P_Y is a corrupted pixel. The possible cases of processing the pixel:
Case (i): If the selected window contains all 0's and 255's, then P_Y is replaced with mean of the elements in the window.
Case ii): If all the elements in the selected window does not have O's and 255's, eliminate 0's and 255's, sort in the ascending order and find the median value of the remaining elements. Replace P_Y with the median value.
Step 5: Repeat steps 2 to 4 until all the pixels in the entire image is processed.
Step 6: Repeat steps 2 to 5.
Step 7: Remove additionally inserted Rows & Columns of 0's in step 1.

V. DISCRIPTION OF AMBBUTMF ALGORITHM

The given image should verify for the presence of impulse noise. If it is noisy, add additional zeros around the comers of the image (512 x 512) in order to preserve the edge details. Now the size of the image becomes 514 x 514**,** then it is easy to process the image with a window of size 3x3, and the processing element as $P_{Y.}$

0	0	0	0	0	0
0					0
0		Image			0
0					0
0					0
0	0	0	0	0	0

Case i): If the processing pixel is not a 0 or 255. Then it doesn't require any processing as indicted in the following example.

$$\begin{bmatrix} 12 & 15 & 98 \\ 34 & <25> & 16 \\ 22 & 67 & 66 \end{bmatrix}$$

Where, "25" is the processing pixel (P_Y). Since "25" is a noise free.

Case ii): If the processing pixel is either 0 or 255 and all the elements in the window are also 0's and 255's, then it requires processing as illustrated.

$$\begin{bmatrix} 255 & 255 & 0 \\ 0 & <0> & 255 \\ 255 & 255 & 0 \end{bmatrix}$$

Where, "0" is the processing pixel (P_Y)' Since all the elements in the window are 0's and 255's. Now the processing pixel should not be replaced with median value, because the median value again becomes either 0 or 255. To avoid this problem processing pixel value should be replaced with mean value. Here the mean value is 170. Replace the processing pixel with 170.

Case iii): If the selected window has the processing pixel value as either 0 or 255 and the remaining pixel values are noisy as well as noise free values, then it requires processing as illustrated.

$$\begin{bmatrix} 167 & 215 & 0 \\ 128 & <0> & 255 \\ 223 & 211 & 90 \end{bmatrix}$$

Where, "0" is the processing pixel P_Y. To eliminate the noise from the selected window, first arrange the above matrix in 1-D array as [167 215 0 128 0 255 223 211 90]. After elimination of 0's and 255's the pixel values in the selected window will be [167 215 128 223 211 90]. Here the median value is 189. Replace the processing pixel P_Y with 189.

VI. RESULTS AND DISCUSSION

The proposed method is tested for only salt and pepper noise by using 512x512 gray scale images. The noise density is varied from 10% to 90%. Denoising performances are quantitatively measured by MSE and PSNR.

Peak Signal to Noise Ratios (PSNR) values to determine image quality:

$$PSNR\ in\ dB = 10log_{10}\left(\frac{255^2}{MSE}\right)$$

$$MSE = \frac{\sum_i \sum_j (\gamma(i,j) - \gamma(i.j)^2)}{M \times N}$$

Where MSE is the mean square error of the two images. Higher values of PSNR mean that the noisy-image is more similar to that of the original image.

Figure 1 & 2 shows the results for 50% and 90% corrupted

Lena image and the restoration by existing and proposed methods.

The role of color descriptors has been demonstrated to be quite remarkable in many visual assessment tasks. In some other tasks, texture measurements are needed because of irregularly colored or unusual surfaces. As stated before, we have involved size and shape as well as color and texture. The simulation are performed to discuss super resolution, registration, restoration and transformation technique after this result performed, we will apply salt and pepper noise removal based on nonlocal mean filter technique. So first image will act as reference image and we will convert the second image in to the reference co-ordinate system. Here modified BPANN based unsymmetric trimmed median filter is applied to remove the noise and enhanced the image quality.
Original image or input images have a RGB combination. Image processing begins with an image acquisition process. The two elements are required to acquire digital images.

EXPERIMENTAL RESULTS OF DIFFERENT IMAGES

Figure 2: Original Image a

Figure 3: Original Image b

The first one is a sensor; it is a physical device that is sensitive to the energy radiated by the object that has to be imaged. The second part is called a digitizer. It is a device for converting the output of the sensing device into digital form. For example in a digital camera, the sensors produce an electrical output proportional to light intensity. The digitizer converts the outputs to digital data. During the process of image acquisition noises are introduced.
Convert RGB image or color map to gray scale. First of all we have to convert RGB or color image into gray image by eliminating the hue and saturation information while retaining the luminance. If the input is an RGB image, it can be single, uint eight, uint sixteen, double, or. The output image I has the same class as the input image.

Here original image is considered as input image or reference image.

The final super resolution image which is obtained after applying the restoration stage using discrete wavelet transform and fusion algorithm. Here input image is the blurred image and removing the blurred and darkness of the image and get the original and high resolution pixel image.

Fig 4 Image used for restoration

Figure 5 (a) Image noise removal lossless mode

Fig 5 (b) Image noise removal Salt and Pepper noise

Fig 5 Image noise removal

Here used the modified trimmed filter for gray image, first way to apply lossless mode to remove the noise after that add the salt and pepper noise in the image with the padding after a certain iterations apply the components of salt & pepper noise in the image. Now on this stage apply the modified BPANN based unsymmetric trimmed median filtered, with the help of this filter remove the noise from the image get the output. After this stage calling a new function in Matlab to remove the added padding and again measure the quality of the output image and also find out the performance parameters.

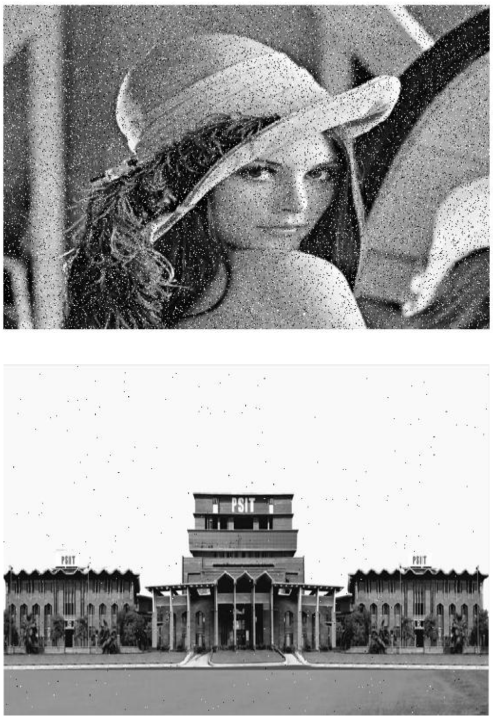


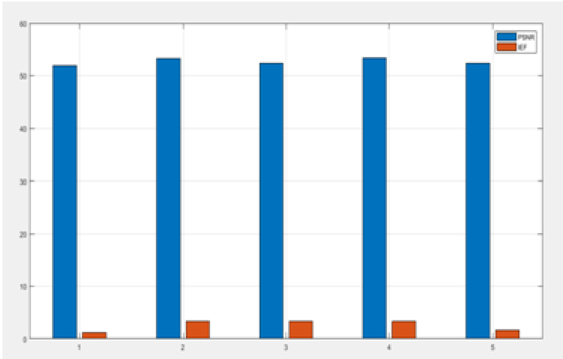
Figure 6: Lena & College Image noise removals

The purpose of calculating the performance of the image and after that comparison between then, will show which method is better for noise removing. Such method is mainly due to highly accurate noise detection experienced by the noise detection algorithm having high noise detection ratio and our method performs more desirable than the median filter and other conventional edge preserving method. The (Peak signal to noise ratio) PSNR, (Signal to noise ratio) SNR is high; (mean squared error) MSE is low. This advised method is a fast method for removing salt and pepper noise.

Table 1: Performance Table for same image but for different format

S. No	PSNR	IEF	Image Format
1	51.9125	1.2049	Lena.jpg
2	53.3042	3.3136	College.jpg
3	52.4130	3.2831	College.png
4	53.3813	3.2919	College.bmp
5	52.3922	1.6259	College.gif

The above performance table 1 shows different images format (.jpg, .png, .bmp, .gif) and evaluate the PSNR and IEF values.



1=lena.jpg; 2=college.jpg; 3=college.png; 4=college.bmp; 5=college.gif
Figure 7: Bar chart of PSNR & IEF

Now we will depict how images recovered when we add noise in an image. First of all we add noise 10% and after that we will increase noise up to 90% and then we extract these images so that useful information can be extracted. We remove salt and pepper noise in our dissertation.

Fig 8: Original Image of Kalam in which noise will be introduced

Fig 9 Original Image with 40% noise

Figure 10 Original Image with recovered after applying algorithm

Figure 10 shows original image of Kalam recovered with 40% noise after applying algorithm.

Fig 11 Original Image of Agni in which noise will be introduced

Figure 11 shows original Image of Agni in which noise will be introduced.

Fig 12 Original Image with 40% noise

Figure 12, we use 40% noise has been introduced with original image of Agni.

Fig 13 Original Image with recovered after applying algorithm

Figure 13 shows original image of Agni recovered with 40% noise after applying algorithm.

Fig 14 Original Image College in which noise will be introduced

Figure 14 shows original Image College in which noise will be introduced.

Fig 15 Original Image with 40% noise

Figure 15 we use 40% noise has been introduced with original image of College**.**

Fig 16 Original Image with recovered after applying algorithm

Figure 16 shows original image of College recovered with 40% noise after applying algorithm.

Fig 17 Original Image of ModiJi in which noise will be introduced

Figure 17 shows Original Image of ModiJi in which noise will be introduced.

Fig 18 Original Image with 40% noise

Figure 18, we use 40% noise has been introduced with original image of Modi ji.

Fig 19 Original Image with recovered after applying algorithm

Figure 19 shows original image of Modi ji recovered with 40% noise after applying algorithm.

Now we will consider different images at a particular noise level and find out their respective parameters PSNR, MSE and IEF.

Table 2 Parameters value for different image for Noise 20%

Image Name	MSE	PSNR	IEF
lena	3.0876e-04	48.4976	1.3451
Kalam	1.1011e-04	40.8651	0.4746
Modi	3.0447e-04	48.5344	1.3669
College	1.4574e-04	53.0020	3.7494
Agni	3.7591e-04	47.3170	1.2766

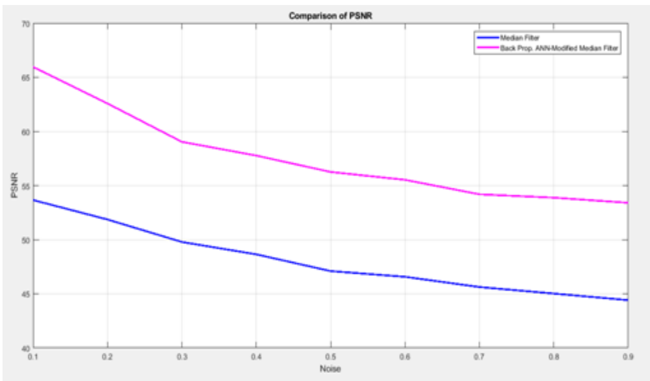


Fig 20: Comparison of PSNR

Fig 20 shows the comparison of PSNR between median filter based techniques and BPANN modified median filter based techniques and BPANN based filter technique is better.

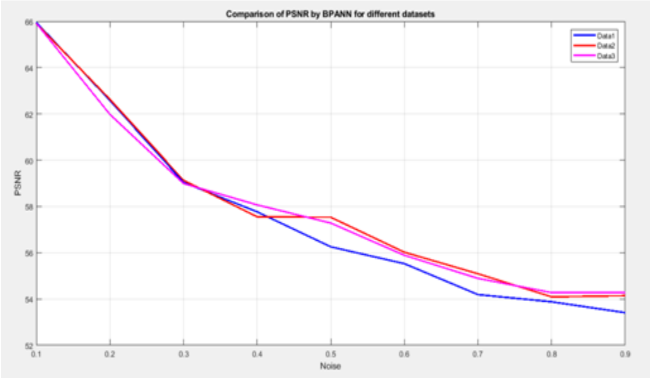


Fig 21: Comparison PSNR by BPANN for different datasheets (images)

The comparison of PSNR for various datasets have been shown in Fig 21. Similarly many other images can be taken to compare the PSNR with little bit difference.

VII. Conclusion

In general, a new algorithm Back Propagation ANN based Advanced modified back propagation based unsymmetrical trimmed median filter (**AMBBUTMF)** is proposed and implemented for different de noising images of different formats. Simulation results clearly shows that the proposed method is quite better in removing the noise with high density compared with the existing methods in terms of PSNR and MSE. The performance of this method is tested for different noise densities with gray scale images. Particularly at high noise densities the proposed method is better in removing the effect of noise. This method is also applicable for another type of noises like speckle, Gaussian, random etc.

References

[1] Gonzalez R., Woods R. “Digital Image Processing” 2/E, Prentice Hall Publisher, 2002.

[2] R. H. Chan, Chung-Wa Ho, M. Nikolova, “Salt and Pepper Noise Removal by Median Type Noise Detectors and Detail Preserving Regularization,” IEEE Transactions on Image Processing, Vol. 14, No.10, pp. 1479-1485, October 2005.

[3] H. Hwang and R. A. Hadded, “Adaptive median filter: New algorithms and results,” IEEE Trans. Image Process., vol. 4, no. 4, pp. 499–502, Apr. 1995.

[4] S. Zhang and M. A. Karim, “A new impulse detector for switching median filters,” IEEE Signal Process. Lett., vol. 9, no. 11, pp. 360–363, Nov. 2002.

[5] P. E. Ng and K. K. Ma, “A switching median filter with boundary discriminative noise detection for extremely corrupted images,” IEEE Trans. Image Process., vol. 15, no. 6, pp. 1506–1516, Jun. 2006.

[6] K. S. Srinivasan and D. Ebenezer, “A new fast and efficient decision based algorithm for removal of high density impulse noise,” IEEE Signal Process. Lett., vol. 14, no. 3, pp. 189–192, Mar. 2007.

[7] V. Jayaraj and D. Ebenezer, “A new switching-based median filtering scheme and algorithm for removal of high-density salt and pepper noise in image,” EURASIP J. Adv. Signal Process., 2010.

[8] K. Aiswarya, V. Jayaraj, and D. Ebenezer, “A new and efficient algorithm for the removal of high density salt and pepper noise in images and videos,” in Second Int. Conf. Computer Modeling and Simulation, 2010, pp. 409–413.

[9] S. Esakkirajan, T. Veerakumar, Adabala N. Subramanyam, and C. H. Prem Chand, “Removal of High Density Salt and Pepper Noise through Modified Decision Based Asymmetric Trimmed Median Filter”, IEEE Signal Process. Lett., vol. 18, no. 5, May 2011.

[10] J. Astola and P. Kuosmanen, Fundamentals of Non Linear Digital Filtering, BocRaton, CRC, 1997.

[11] V. Jayaraj and D. Ebenezer, “A new switching-based median filtering scheme and algorithm for removal of high-density salt and pepper noise in image,” EURASIP J. Adv. Signal Process., 2010.

[12] J.Astola and P.Kuosmaneen, Fundamentals of Nonlinear Digital Filtering. Boca Raton, FL:CRC,1997.

[13] H.Hwang and R.A.Hadded, "Adaptive median filter: New algorithms and results," IEEE Signal Process., vol. 4, no. 4, pp.495-502, Apr. 1995.

[14] SZhang and M.A.Karim, "A new impulse detector for switching median filters," IEEE Signal Process. Lell .. vol. 9, no. 11, pp.360-363, Nov. 2002.

[15] P.E.Ng and K.K.Ma, "A switching median filter with boundary discriminative noise detection for extremely corrupted images," IEEE Trans. Image Process., vol. 15, no. 6, pp. 1506-1516, Jun. 2006.

[16] R. Gonzalez and R. E. Woods. Digital Image Processing. Prentice Hall, Upper Saddle River, New Jersey, third edition, 2007.

[17] K.S.Srinivasan and D.Ebenezer, "A new fast and efficient decision based algorithm for removal of high density impulse noise ," IEEE Signal Process. Lell .. vol. 14, no. 3, pp. 189-192, Mar. 2007.

[18] K.Aiswarya, V.Jayaraj" and D.Ebenezer. "A new and efficient algorithm for removal of high density salt and pepper noise in images and videos," in Second Int. Con! Computer Modeling and Simulation, 2010, pp. 409-413.

[19] P. Perona and J. Malik. Scale-space and edge detection using anisotropic diffusion. IEEE Trans. on Pattern Analysis and Machine Intelligence, 12(5):629–639, May 1990.

[20] K. N. Plataniotis and A. N. Venetsanopoulos. Color Image Processing and Applications. Springer, Heidelberg, Germany, first edition, 2000.

[21] S.Esakkirajan, T.Veerakumar, Adabala N.Subramanyam, and C.H.Prem Chand, "Removal of high density salt and pepper noise through modified decision based Asymmetric trimmed median filter," IEEE Signal Process. Lell., vol. 18, no. 5, pp. 287-290, may 2011.

[22] Y. Xiao, T. Zeng, J. Yu, and M. K. Ng. Restoration of images corrupted by mixed Gaussian-impulse noise via l1 -l0 minimization. Pattern Recognition, 44(8):1708–1720, 2011.

[23] C. Tomasi and R. Manduchi. Bilateral filtering for gray and color images. In Proc. of IEEE International Conference on Computer Vision, Bombay, India, 1998.

[24] D. R. K. Brownrigg, "The Weighted Median Filter," Comm. ACM, vol. 27, pp. 807-818, August 1984. Marco Fischer, Jose L.Paredes and Gonzalo.R. Arce, "Weighted Median Image Sharpeners for the Word Wise Web." IEEE Transactions on Image Processing, vol. 11, no. 7, pp. 717-727,July 2002

[25] T. Chen and H.R. Wu, "Adaptive Impulse Detection Using Center-Weighted Median Filters." IEEE Signal Processing Letters, vol. 8, no. 1, pp.1-3, Jan 2001.

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