International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-11, Feb 2019

Decision Based Impulse Denoising Techniques for Gray Scale Images: An Experimental Analysis

Usha Rani, Assistant Professor, University College Ghanaur, Patiala, Punjab, India.

usha_gupta7@yahoo.co.in

Abstract - **In digital images, salt and pepper noise is introduced during acquisition, transmission or due to faulty memory locations etc. This is a type of noise that takes only extreme values that is white and black in gray level images. The presence of this noise is undesirable in digital images as it effects the subsequent stages of the digital image analysis such as image enhancement, segmentation and recognition etc. There exist many approaches to remove the salt and pepper noise in the literature. This paper, analyze the decision-based techniques to remove high density salt and pepper noise: Modified decision based Un-symmetric Trimmed Median Filter (MDUBTMF), Improved Decision Based Asymmetric Trimmed Median Filter (IDBATMF) and Decision based Adaptive Neighborhood Median Filter (DBANMF). The results show that DBANMF is the best to denoise gray level images. But in case real image contains the extreme intensity values (i.e. 0 and 255), DBANMF does not perform properly. On the other hand, IDBATMF is better in identifying whether the extreme intensity values belong to noise or real image, but it is poor in denoising the gray level images with high density noise in comparison to DBANMF.**

Keywords —Decision based techniques, gray scale image, image denoising, impulse noise, median filter, salt and pepper noise.

I. INTRODUCTION

Salt-and-pepper noise also known as impulse noise is an additive noise which presents itself as white and black points sprinkled all over an image. It looks like mixture of salt and pepper and can be found in almost all binary, gray level and colored document images. It is undesirable to have such noise in digital images as it degrades the performance of image processing operations such as image enhancement, image segmentation and recognition etc. There exist many techniques to remove such noise. Most prevalent denoising techniques are nonlinear filtering techniques such as standard median filter (SMF) [1], center weighted median filters (CWMF) [2], adaptive median filter (ADMF) [3], Adaptive Centre Weighted Median Filter (ACWMF) [4], Tri-State Median Filter (TSMF) [5] etc. The major drawback of these filters is that, these work effectively for low noise densities. As noise density increases, window size needs to be increased to get better noise suppression, but it causes blurring of the edges. These methods process each pixel in the image irrespective of whether it is noise pixel or not, that results unwanted smoothening and the loss of fine details of the image.

To overcome the above drawback, decision based impulse denoising techniques are proposed by many authors. Modified decision based Un-symmetric Trimmed Median Filter (MDUBTMF) [6], Improved Decision Based Asymmetric Trimmed Median Filter (IDBATMF) [7] and Decision based Adaptive Neighborhood Median Filter (DBANMF) [8] are the decision based denoising techniques which are specially developed to denoise the images corrupted with high density impulse noise. In the nonlinear filtering techniques, all the pixels of the image are processed regardless of whether these are corrupted pixels or not. In decision based denoising techniques, firstly corrupted pixels are detected and then decision is taken to process only those pixels. The pixels with intensity values other than '0' and '255' remain unchanged and pixels having intensity values '0' and '255' are processed.

This paper presents the comparative analysis of the decision based denoising methods: MDUBTMF, IDBATMF and DBANMF. The rest of the paper is organized as follows: The full details of techniques considered for comparison are described in Section 2. The Section 3 presents the experimental details and results. The summary of results is given in section 4. Section 5 draws the conclusions.

II. DECISION BASED DENOISING TECHNIQUES

The decision based denoising techniques first detects the corrupted pixels and then decision is taken to process these corrupted pixels based on some criterion. This section discusses the Modified Decision based Un-symmetric Trimmed Median Filter (MDUBTMF) [6], Improved Decision Based Asymmetric Trimmed Median Filter (IDBATMF) [7] and Decision based Adaptive Neighborhood Median Filter (DBANMF) [8] which are

 DOI : 10.18231/2454-9150.2019.0081

specifically designed to remove high density impulse noise from digital images.

A. Modified decision based Un-symmetric Trimmed Median Filter (MDUBTMF)

Esakkirajan et al. [6] proposed a filter named Modified decision based Un-symmetric Trimmed Median Filter (MDUBTMF) to removal salt and pepper noise which first detects the impulse noise by scanning the image pixel by pixel and process as below:

- If the pixel is uncorrupted, it is left unchanged.
- If it is corrupted (i.e. 0 or 255), then pixels in 3×3 neighborhood is checked. All pixels with intensities values 0's and 255's is replaced with median or mean of the remaining pixels in the window.

This method assumes all pixels with intensity values '0' and '255' as noisy pixels.

B. Improved Decision Based Asymmetric Trimmed Median Filter (IDBATMF)

Kesharwani et al. [7] proposed an Improved Decision Based Asymmetric Trimmed Median Filter (IDBATMF) to remove salt and pepper noise from gray scale images. In this method, image is scanned pixel by pixel, if pixel is uncorrupted (having intensity value other than 0 and 255), it is left unchanged. Otherwise, a 3×3 neighborhood around the pixel having intensity value 0 or 255 is considered and the decision is taken as follows:

- If the neighborhood contains pixels with 0, 255 and other random values, the pixel at the center is replaced with the trimmed median value of the elements in the neighborhood.
- If all the pixels in the neighborhood having intensity values 0 or 255, then decision is taken based on the numbers of 0 and 255 intensity values in the neighborhood.
  - ➢ If number of pixels with intensity values of 0 (or 255) are more than 6, the considered pixel is replaced with 0 (or 255).
  - ➢ Else the pixel being processed replaced with the mean of the intensity values of all pixels in the neighborhood.

C. Decision based Adaptive Neighborhood Median Filter (DBANMF)

Samantaray and Mallick [8] proposed another Decision based Adaptive Neighborhood Median Filter (DBANMF) that similar to MDUBTMF, considers every pixel having gray value '0' or '255' as a noisy pixel. The image is scanned pixel by pixel, uncorrupted pixel values (Which are not having gray value '0' or '255') are left unchanged. In case noisy pixel is detected, a 3×3 neighborhood is considered by taking the noisy pixel as the center of the window. Filtering process consists of three phases as follows:

- Firstly, it checks only first order neighborhood pixels. If one uncorrupted pixel is found, then that uncorrupted pixel value replaces the corrupted center pixel. If there is more than one uncorrupted pixel among first order neighborhood then median of uncorrupted pixels replace the corrupted center pixel.
- If there is no uncorrupted pixel in first order neighborhood. then in the second phase only diagonal pixel values are considered. If there is only one uncorrupted value in diagonal neighbors, that uncorrupted pixel value replaces corrupted center pixel. If there is more than one uncorrupted value in diagonal neighbors then median of those uncorrupted pixels replaces the corrupted center pixel value.
- If there is no uncorrupted pixel in the full 3x3 neighborhood, then third phase replaces the corrupted center pixel with the mean of all neighborhood pixels. This method is applied iteratively until all the noisy pixels are removed from the image.

This method is able to perform well in low density as well as high density of noise but it fails to restore the pixels with extreme intensity values that is black and white. Because it considers every black and white pixel in the image as noise and replace its value with other uncorrupted pixel or median of the uncorrupted pixels.

III. Experimental Details and Results

A. Experimental Details

To evaluate the performance of above discussed algorithms, experiments are conducted using gray scale images in Fig. 1, Fig. 2 and Fig. 5. Impulse noises from 10 to 90 percentage are added to the images and their PSNR (Peak Signal to Noise ratio) and EPI (Edge Preservation Index) values are calculated.

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise. It is expressed in terms of the logarithmic decibel scale. The higher the PSNR value, the better the quality of enhanced image.

EPI calculates the amount of edges preserved in the image after denoising. When an impulse noise is available in a given image, denoising removes the edges to a certain extent. To ensure that the resultant image after denoising preserves edges there is an index called Edge Preservation Index (EPI) given by [9]. Its value lies between 0 to1.

The PSNR and EPI values for image in Fig. 1 are calculated and are tabulated in Table 1. The PSNR and EPI

results are also shown pictorially in Fig 3. and Fig. 4.

 DOI : 10.18231/2454-9150.2019.0081

B. Experimental Results and Discussion

1. The performance of Standard Median Filter (SMF) is the lowest than all the denoising techniques considered here. It works well up to 40% of noise density.

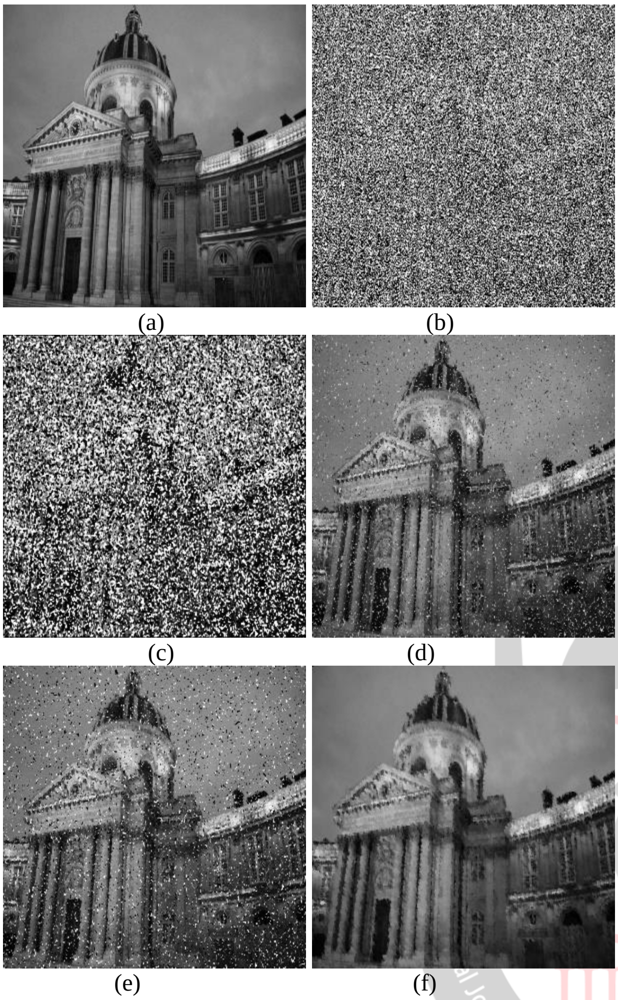

Fig. 1. Results of image with 80% noise density: (a) Original Image, (b) Image with 80% noise, (c) Output of SMF, (d) Output of MDUBTMF, (e) Output of IDBATMF, (f) Output of DBANMF

2. Fig. 1 and Fig. 2 shows the visual results of the gray scale image with 80% and 90% noise density, which shows that DBANMF is best in restoring such images with high noise density. It is also clear from the Table 1, Fig. 3 and Fig. 4 that DBANMF produces highest PSNR and EPI values for the image in Fig. 1. EPI results show that DBANMF highly preserves the edges even at very high noise density. MDUBTMF is the second best in terms of PSNR as well as EPI.
3. Fig. 5 shows the restoration results of the image with 40% noise density. In this figure, real image contains the pixels with extreme values that is 0 and 255. These areas are shown within the red and green circles. Red circle contains the pixels with 0 values and green circle shows the pixels with intensity value 255. These pixels with extreme values are not well restored by the MDUBTMF and DBANMF methods, while IDBATMF and SMF are able to restore these pixels. This is due to reason that MDUBTMF and DBANMF assumes all pixels having 0 or 255 values as noisy pixels and replace its value with other uncorrupted pixel or median of the uncorrupted pixels. So, the image denoised using MDUBTMF and DBANMF will not have any pixels with extreme gray values that is black and white. But in reality, it is possible to have certain black or white pixels in the real image.

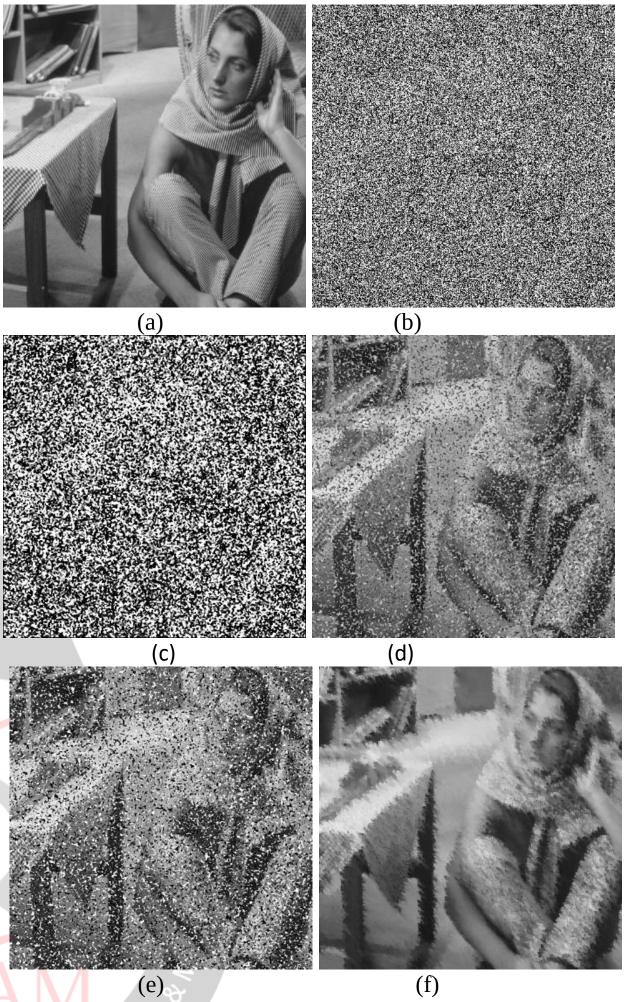

Fig. 2. Results of image with 90% noise density: (a) Original Image, (b) Image with 90% noise, (c) Output of SMF, (d) Output of MDUBTMF, (e) Output of IDBATMF, (f) Output of DBANMF.

Table 1. PSNR and EPI values with different methods at various noise densities of image in Fig. 1.

	SMF		MDUBTMF		IDBATMF		DBANMF	
	PSNR	EPI	PSNR	EPI	PSNR	EPI	PSNR	EPI
10%	29.42	0.706	38.76	0.948	38.76	0.948	41.03	0.967
20%	26.69	0.640	35.06	0.894	35.06	0.894	36.92	0.928
30%	22.82	0.543	32.66	0.834	32.65	0.834	33.98	0.881
40%	18.49	0.433	30.80	0.770	30.67	0.770	31.79	0.823
50%	14.91	0.360	28.79	0.707	28.18	0.703	29.33	0.759
60%	12.18	0.331	26.33	0.627	24.69	0.618	27.37	0.673
70%	9.79	0.329	22.96	0.534	20.37	0.501	25.49	0.584
80%	7.97	0.338	19.02	0.417	15.82	0.380	23.13	0.484
90%	6.45	0.338	15.01	0.345	11.49	0.333	20.65	0.371

4. The above issue of presence of black and white pixels in the real image is handled by the IDBATMF method. If the number of pixels with intensity values of 0 (or 255)

 DOI : 10.18231/2454-9150.2019.0081

are more than 6 in the 3×3 neighborhood of the pixel having intensity value 0 or 255, the considered pixel is replaced with 0 (or 255). But another problem is here that in case images having high noise density, the number of black (or white) pixels in the vicinity of the under process corrupted black (or white) pixel can be more than six, then this pixel will be taken as the part of real image and included in the denoised image. That is why, at high noise densities this method does not perform well.

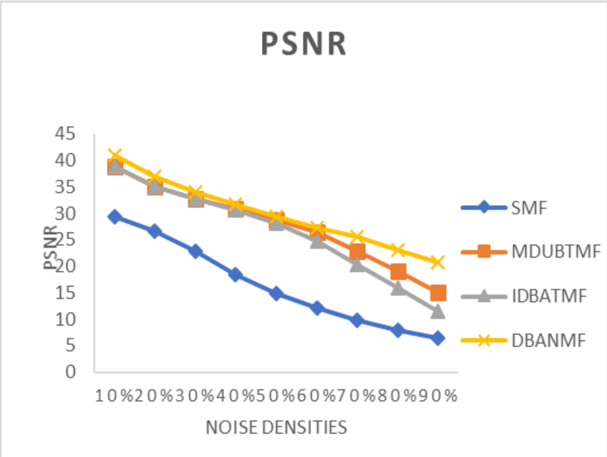

Fig. 3 PSNR values of image in Fig. 1 at various noise densities

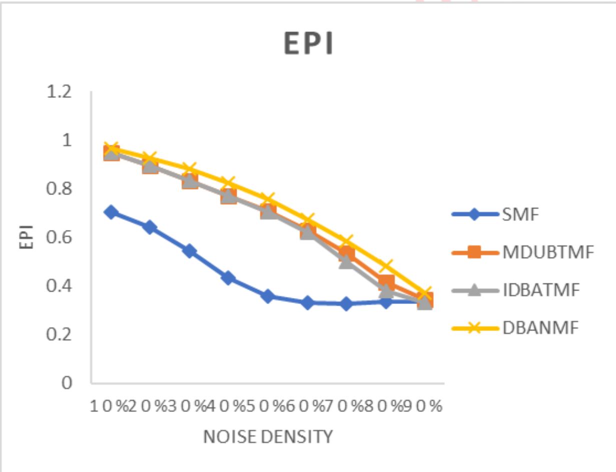

Fig. 4: EPI values of image in Fig. 1 at various noise densities

IV. CONCLUSIONS AND FUTURE WORK

This paper presents the experimental analysis of decision based impulse noise removal techniques. The experimental results show that DBANMF is the best technique to denoise the gray scale images even at high noise density and MDUBTMF is the second best. But problem with these techniques is that they are unable to restore images properly if these images contain black and white pixels in reality. On the other hand, IDBATMF is better in identifying the black and white pixels whether these belong to real image or to the noise. But, at high noise density the performance of IDBATMF degrades more compared to the MDUBTMF and DBANMF. According to the discussion presented in the paper, there is a scope to develop a denoising technique which is good to restore image with high noise density as DBANMF and can properly handle the black and white pixels in the real image as IDBATMF.

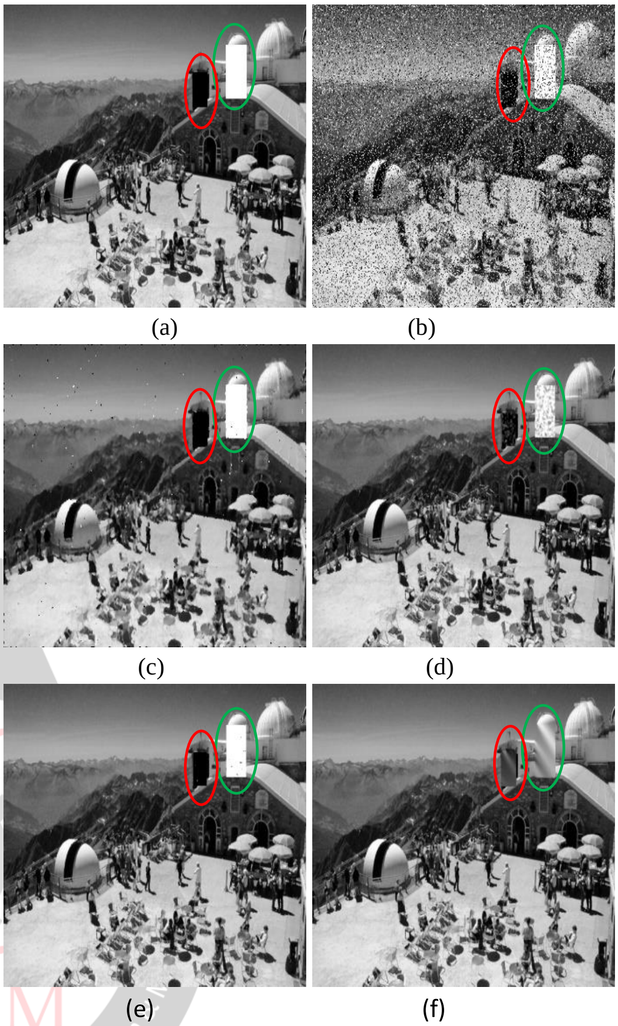

Fig. 5 (a) Gray Scale Image having extreme values that is black and white pixels as part of the real image: Black patch is shown in red circle and white patch is shown in green circle, (b) Image with 40% noise, (c) Output of SMF, (d) Output of MDUBTMF, (e) Output of IDBATMF, (f) Output of DBANMF.

REFERENCES

[1] M. Sonka, V. Hlavac and R. Boyle, “Image Processing. Analysis and Machine Vision,” Second ed: PWS, 1999.

[2] T. Sun, M. Gabbouj, Y. Neuvo, “Analysis of two-dimensional center weighted median filters,” *Multidimensional Systems and Signal Processing*, vol. 6, no. 2, pp. 159-172, 1995.

[3] Y. Zhao, D. Li, Z. Li, “Performance enhancement and analysis of an adaptive median filter,” In 2007 International Conf. on Commun. and Networking, pp. 651-653, 2007.

[4] S. J. Ko, Y. H. Lee, “Centre weighted median filters and their applications to image enhancement,” IEEE Transactions on Circuits and Systems, vol. 38, no. 9, pp. 984-993, 1991.

[5] T. Chen, K. K. Ma and L. H. Chen, “Tri-State Median Filter for Image Denoising,” IEEE Transactions on Image Processing, vol. 8, no. 12, pp. 1834-1838, 1999.

 DOI : 10.18231/2454-9150.2019.0081

[6] S. Esakkirajan, T. Veerakumar, A. N. Subramanyam and C. H. PremChand, “Removal of high-density salt and pepper noise through modified decision based unsymmetric trimmed median filter,” IEEE Signal Processing Letters, vol. 18, no. 5, pp. 287-290, 2011.

[7] A. Kesharwani, S. Agrawal, M. K. Dhariwal, “An improved decision based asymmetric trimmed median filter for removal of high-density salt and pepper noise,” International Journal of Computer Applications. vol. 84, no. 8, pp. 37-43, 2013.

[8] A. K. Samantaray, P. Mallick, “Decision based adaptive neighbourhood median filter,” Procedia Computer Science, vol. 48, pp. 222-227, 2015.

[9] F. Sattar, “Image Enhancement based on a Nonlinear multi scale method,” IEEE Trans on Image Processing, vol. 6, no. 6, 1997.

[10] E. J. Leavline, D.A.A.G. Singh, “Salt and pepper noise detection and removal in gray scale images,” International Journal of Signal Image Processing and Pattern Recognition, vol. 6, no. 5, pp. 343-352, 2013.

 DOI : 10.18231/2454-9150.2019.0081