AN EFFICIENT APPROACH FOR NON LINEAR FILTER DESIGN IN SPATIAL DOMAIN FOR HIGH DENSITY IMPULSE NOISE REMOVAL IN DIGITAL IMAGES

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Abstract- A spatial domain non linear filtering algorithm for the restoration of gray scale, and Color images that are corrupted by high density impulse noise is proposed. The proposed algorithm well suited for suppressing impulse and also Gaussian noises with different noise leves.It shows better results than the Standard Median Filter (MF), Trimmed Median Filter (TMF) and Weighted Median Filter. Experiment Result shows the proposed algorithm has advantages over regularizing methods in terms of both edge preservation and noise removal and it gives the better Peak Signal to Noise Ratio (PSNR) compared to other techniques even in the high noise densities.

Keywords- Different noises (Gaussian and Impulse Noises), Non linear filters, heavily contaminated image.

I. INTRODUCTION

Images are often corrupted by different types of noise primarily impulse noise and Gaussian noise during the course in which they were generated or transmitted. The most well-known version of the noise in images is the salt and pepper noise [1]. The noise which sprinkles on the images like white and black dots significantly reduces the visual effects of images. The common filtering algorithms are not effective to remove the noise, especially for heavy noise. To suppress the high density noise and improve image quality, it's very important to keep the margins and details as well as removing noises in images. Several nonlinear filters have been proposed for restoration of images contaminated by salt and pepper noise. Among these standard median filter has been established as reliable method to remove the salt and pepper noise without damaging the edge details. However, the major drawback of this Filter is that the filter is effective only at low noise densities [1].When the noise density is over 40% the edge details of the original image will not be preserved by standard median filter. Weighted Median Filter (WMF) [2] performs well at low noise densities, in which the output is a weighted sum of the image and a denoising factor, these weighting coefficients depend on a state variable. The state variable is the difference between the current pixel and the average of the remaining pixels in the surrounding window. Because the coefficients are various, it's difficult to select an appropriate one. But at high noise densities the window size has to be increased which may lead to blurring the image. In this, image is denoised by using a 3*3 window. If the processing pixel value is 0 or 255 it is processed or else it is left unchanged. At high noise density the median value will be 0 or 255 which is noisy. In such case, neighboring pixel is used for replacement. This repeated replacement of neighboring pixel produces streaking effect [6]. Eventhough, the trimmed median filter is filtered the noise at high noise densities, trimmed median value cannot be obtained if the selected window contains all 0's or 255's or both. So this algorithm does not give better results at very high noise density that is at 70% to 80%.

To overcome this problem, a new filtering technique called spatial domain non linear filtering algorithm is proposed. This technique is well suited to remove the noise either in low noise level or in high noise level. This is most suitable for denoising of both impulse and Gaussian noise compared to other filtering technique. It also gives the better Peak Signal to Noise Ratio (PSNR) values than the existing algorithm. The rest of the paper is structured as follows. A brief introduction of Existing algorithm is given in Section II. Section III describes about the proposed algorithm and the detailed description of the proposed algorithm with an example is presented in Section IV. Simulation results with different images are presented in Section V. Finally conclusions are drawn in Section VI.

II. OVERVIEW ON EXISTING FILTERS

On earlier, there were different filtering techniques for denoising the high density impulse noise in the digital images. Standard median filter, Vector and Weighted

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median filter are discussed here. Among these, Standard median filter is one of the non linear filter types for image restoration. Here, the noisy pixel will be replaced by the median value of that respected window [(3*3 or 5*5) matrix]. If the selected window contains salt or pepper noise as processing pixel (i.e., 255/0 pixel value) and after eliminating those 255/0 pixel values, the remaining pixel values are arranged in ascending then find the median value by,

i= [no of data items +1]/2, the final value is ith element of 1D array. For example, The selected window size is 3 * 3 matrix,

$$\begin{matrix} 75 & 95 & 255 \\ 130 & 0 & 135 \\ 0 & 100 & 255 \end{matrix}$$

The 1-D array of the above matrix is [75 95 100 130 135] after eliminating 0/255 pixel intensity
and arrangement. Here the median value is 100.It is not suitable for removal of high density noise.

The vector median filter is established for overcoming the problem of solving the high density noise denoising. It can remove the noise level of greater than 30% compared to median filtering.

For a set of N vectors $x1,\ldots, xN$ *within* a right-angled window and any vector norm $\|.\|_L$

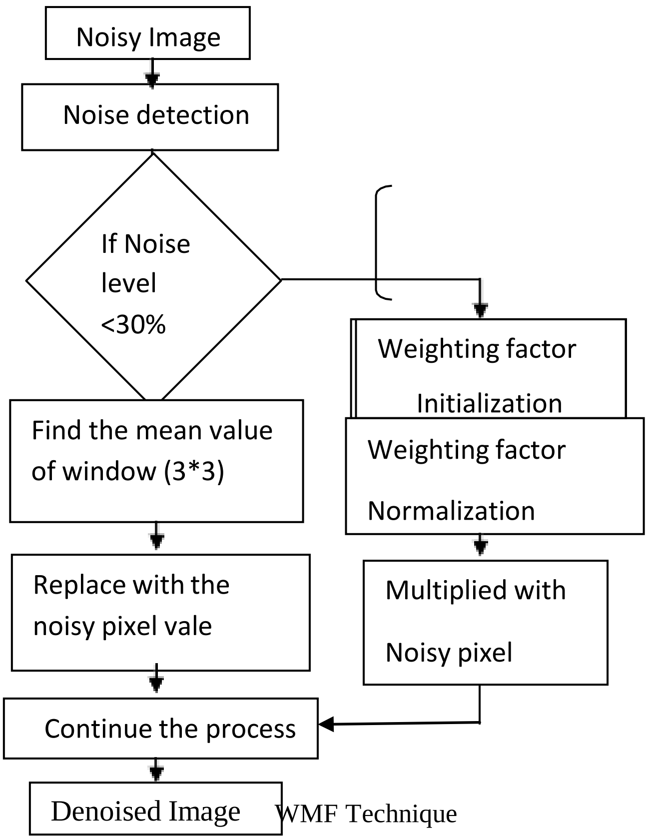
$$VM\{\mathbf{x}1,\mathbf{x}2,\_,\mathbf{x}N\}= \mathbf{x}_{VM} \text{ , where } \mathbf{x}_{VM} \ \varepsilon \ \{\mathbf{x}1,\mathbf{x}2,\_,\mathbf{x}N\}$$

And

$$\sum_{i=1}^{N}\| \mathbf{x}_{VM} - x_i\|_L \leq \sum_{i=1}^{N}\| \mathbf{x}_j - x_i\|_L , j=1, 2,\ldots N$$

The result of this filter operation selects that vector in the window, which minimizes the sum of the distances to the other N -1 vectors regarding the L-norm. It is also has some drawback that the computation of the vector median for the entire color image is quite time consuming and edge preservation lost and it shows poor performance when the noise level is increased and it will be overcome by decision based weighted median filter.

In this technique, first the noise is estimated and based on the level mean or weighted median filter is applied for the effective removal of noisy pixel. The fig1 shows the flowchart for weighted median filter technique. The detection process uses neighborhood pixels correlations to divide the pixels into signal pixels and noise pixels. Signal pixels are kept the same and only noise pixels are processed. For filtering block, the different approaches were taken according to the noise density situations. In the low noise density case, neighborhood signal pixels mean method is adopted. In the high noise density case, adaptive weight algorithm is used. The noise level is detected by, L = [number of noise level / (M*N)]. If the L is less than 30% then



WMF Technique

mean filtering is applied to that window [(3*3) or (5*5) matrix] otherwise weighted median filter is applied which is done by, the initial weight coefficient is,

$$T_{a,b} = D_{a,b} * P_{a,b}$$

Where, $D_{a,b}= \begin{cases} (1/ [(X_{i+a,j+b}) - M_{i,j}]) , & f_{i+a,j+b} =0 \\ 0 , & \text{else} \end{cases}$

And $P_{a,b}= \begin{cases} 0 & a=b=0 \\ 0.25 & |a|=|b|=1 \\ 0.5 & \text{else} \end{cases}$

The Normalized weight coefficients,

$d_{a,b} = T_{a,b}/[\Sigma\, \Sigma T_{a,b}]$, where, a,b=-1 to 1

The final summation,

$X_{i,j} = \Sigma\Sigma[X_{i+a,j+b} * d_{a,b}]$ where,a,b=-1to1

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These kind of filtering technique removed the noise at high density like 50% or 60%.But the proposed technique denoised the high contaminated image in the range of 80% -90%.It gives better performance than previous filters. The next section describes the introduction and algorithm about our denoising technique for effective image restoration.

III. PROPOSED TECHNIQUE

Sharpening Spatial Filters

- The principal objective of sharpening is to highlight fine detail in an image or to enhance detail that has been blurred, either in error or as an natural effect of a particular method of image acquisition.

Definition of the 1st-order derivative

$$\frac{\partial f}{\partial x} = f(x + 1) \quad f(x)$$

Definition of the 2nd-order derivative

$$\frac{\partial^2 f}{\partial x^2} = f(x - 1) - f(x - 1) - 2 f(x).$$

Derivative of image profile

IV. THE SIMULATION AND ANALYSIS

A gray-scale or color image whose size is 256× 256 was selected for verification of advantage and effectiveness of proposed filtering algorithm. First salt and pepper noise was added to image and then MF, VMF, WMF and proposed algorithm were used separately to restore the image corrupted by salt and pepper noise. Fig.2 shows the visual results comparison of different methods. Fig.3 shows the plot of Peak Signal to Noise Ratio (PSNR) and Image Enhancement Factor (IEF) comparison of proposed method with different algorithms at various noise ratios for test image. The noise density is varied from 10% to 80% and denoising performance is measured by PSNR and IEF as follows,

PSNR in db = $10\log_{10} (Max^2 / MSE)$

Where, Max –Maximum Intensity of Image

MSE –Mean Square Error which is defined by,

$$MSE = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (Z(i,j) - \bar{Z}(i,j))^2}{(M * N)}$$

$$IEF = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (\eta(i,j) - Z(i,j))^2}{\sum_{i=1}^{M} \sum_{j=1}^{N} (Z(i,j) - \bar{Z}(i,j))^2}$$

Noise Level	PSNR (db) SMF	VMF	WMF	Proposed
0.6				
0.7				

Table I. Comparision of MSE and PSNR Factor for Different algorithms at noise densities

Where, Z represents the original image, $\bar{Z}$ denotes the denoised image, ŋ represents the noisy image. M *N is the size of image. The following plot Fig .2.shows the comparision between proposed and different algorithm.

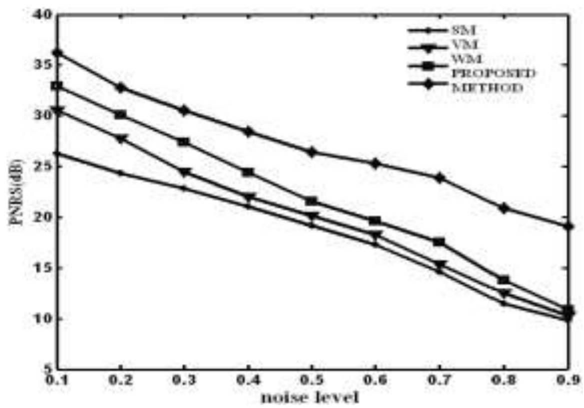

Fig.2. Comparision graph for PSNR at different noise densities

The results of four algorithms have shown that: MF algorithm is applicable for the situation of low noise density; With the noise density of the image increasing, VMF algorithm is more similar to MF algorithm, Their filtering properties get worse with the noise density increasing; Although WMF algorithm is better than MF and VMF algorithms in high density noise situation, it

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still has some shortage either in the filtering result or in preserving the image details, compared with the proposed algorithm. It shows that the restored result of the proposed algorithm is best.

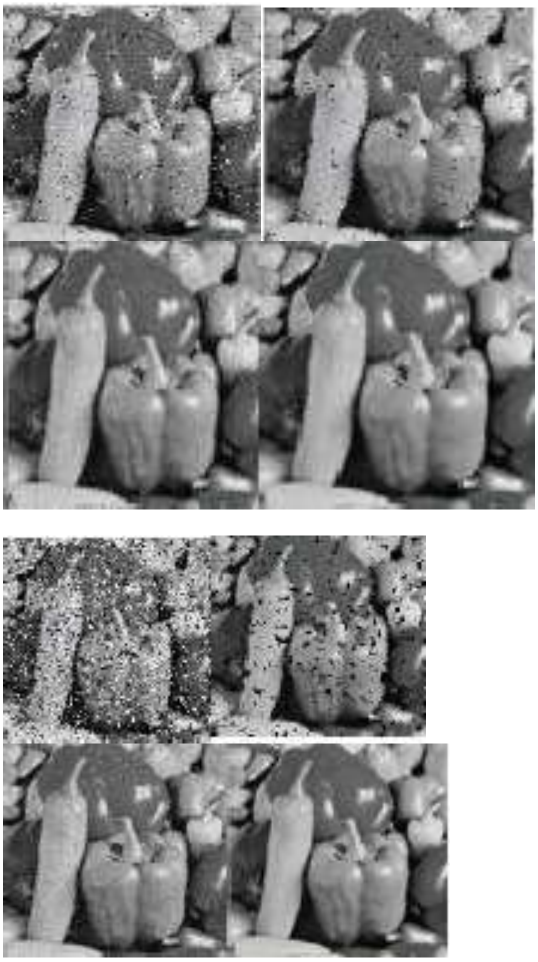

Fig. 3. Results of different algorithms for pepper image. (a) Noisy Image (b) Output of MF. (c) Output of VMF. (d) Output of WMF. (e) Output of Proposed Method. Row 1 and Row 2 shows processed results of various algorithms for image corrupted by 70% and 80% noise densities, respectively.

When the noise density is more than 60%, other algorithm PSNR drops off precipitously. With the noise density improving, the D-value between the proposed algorithm and the other three algorithms is larger. Especially when the noise density is up to 90%, their PSNR D-value is about 10 dB. Experiment shows that the proposed algorithm has better denoising and protection detail capacity.

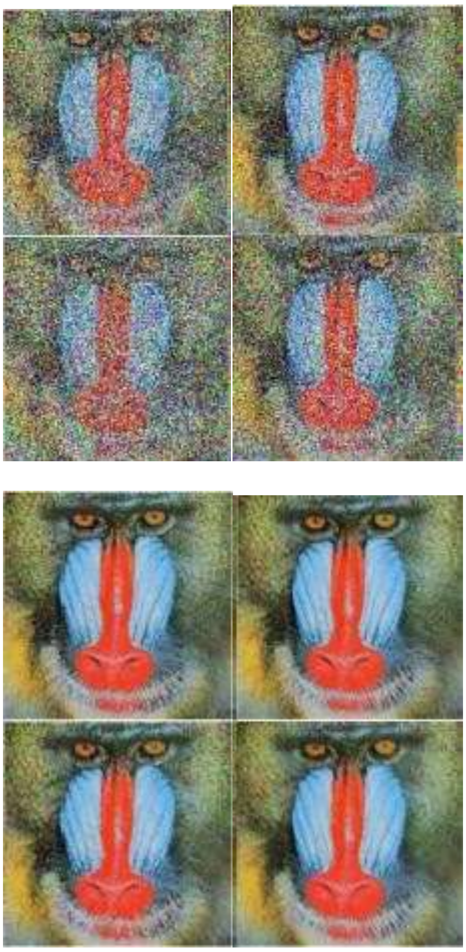

Fig. 3. Results of different algorithms for color baboon image. (a) Output of MF. (b) Output of VMF. (c) Output of WMF. (d) Output of Proposed Method. Row 1 and Row 2 shows processed results of various algorithms for image corrupted by 70% and 80% noise densities, respectively.

V. CONCLUSION

An effective filtering algorithm is proposed for removing the salt and pepper noise at the different noise densities situation. First to detect the noise pixels, then different methods are applied to various noise densities. The performance of the algorithm has been tested at low, medium and high noise densities on both gray-scale and color images. Even at high noise density levels the proposed technique gives better results in comparison with other existing algorithms. Experimental results show that this algorithm can suppress noise effectively. The proposed algorithm is effective for high density case in gray scale as well as color images.

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REFERENCES

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

[2] 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.

[3] S. J. Ko and Y. H. Lee, "Center weighted median filters and their applications to image enhancement ", Pattern Recognit. Lett,15(4):341- 347,1994.

[4] E.Abreu, M.Lightstone, S.Mitra, and K. Arakawa, "A new efficient approach for the removal of impulse noise fromhighly corrupted images", IEEE Trans . Image Processing , 5(6) :1012-1025,1996.

[5] 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.

[6] T. Kasparis, N. Tzannes, and Q.Chen, "Detail-preserving adaptive conditional median filters ",Electron Imag,1(14):358-364,1992.

[7] H. Hwang and R. A. Haddad, "Adaptive median filters: New algorithms and results", IEEE Trans.Image Process.,4(4):499-502,1995.

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