# Eliminating Noise from Mixed Noisy Image by using Modified Bilateral Filter

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***Abstract*—** **Spatial Domain filtering for removing noise from image are popular techniques. However noise can be removed from image in transform domain also; this can be done using Discrete Cosine Transform (DCT) or Discrete Wavelet Transform (DWT) . Transform domain Techniques are better for periodic noise or mixed noise with periodic noise. But to remove Gaussian-impulsive-poisson mixed noise spatial domain filtering is far better. Here is the introduction to spatial domain filtering.**

**To remove noise from images neighborhood processing is to be used. In Neighborhood processing, a function is applied to a neighborhood of each pixel. During this a rectangular mask (usually with sides of odd length) is moved over the given image. As we do this, we create a new image whose pixels have grey values calculated from the grey values under the mask. Mixed noise is considered as mixture of Gaussian noise and impulse noise. Some of the techniques are implemented in the work and analyzed in terms of various performance matrices. By understanding advantages, drawbacks and limitation of these techniques, we proposed an optimum technique for removing mixed noise from color image. We proposed a SBF technique for this purpose.**

***Index Terms*— Bilateral filter*;* Switched Bilateral filter MATLAB; Gaussian-impulse mixed noise; SQMV; SQMR*;***

## I. INTRODUCTION

Noise can be defined as any degradation in the image signal, caused by external disturbance. There are various sources of noise in digital images from the process of acquisition of image in CCD camera or scanners to transmission of image via communication channel. The acquisition process for digital images converts optical signals into electrical signals and then into digital signals and is one process by which the noise is introduced in digital images. Various factors like Dark Current, Pixel Non-Uniformity, Shot Noise, CCD Read Noise, Electronic Interference etc. affect the acquisition process of image. Moreover each step in the conversion process experiences fluctuations, caused by natural phenomena, and each of these steps adds a random value to the resulting intensity of a given pixel. These noises can be modeled as Gaussian noise.

On the other hand another type of noise introduces due to transmission errors or storage faults. If an image is being sent electronically from one place to another, via satellite or wireless transmission, or through networked cable, we may expect errors to occur in the image signal. These errors will appear on the image output in different ways depending on the type of disturbance in the signal. These noises can be modeled as impulse noise.

Both noises are independent to each other and may randomly introduce in image. When a noisy image is further transmitted over faulty transmission line the image will be corrupted by mixture of both types of noises. To remove mixed noise becomes more difficult because in mixed noise property of individual noise tends to changes. For example impulse noise detection becomes difficult in mixed noisy image. Similarly zero mean property of Gaussian noise no longer exists if image is corrupted by other noise also.

Therefore noise specific filters cannot remove mixed noise sufficiently. Like VMF and VDF techniques are suitable for impulse noise only, but cannot remove it from mixed noisy image. Similarly bilateral filter is suitable for Gaussian noise only, but cannot remove it from mixed with impulse noise. Hence there is a need for techniques to remove both the noises from image simultaneously.

## II. MIXED NOISE REMOVAL TECHNIQUES

To date, a few methods have been proposed in literature to make filters that can effectively remove both Gaussian and impulse noise, or any mixture thereof, from color images. These are summarized as follow:

The Peer Group Averaging (PGA) technique presented in [1],[2] and extended to the fuzzy context in [9] removes mixed noise by combining a statistical method for impulse noise detection and replacement with an averaging operation between the (fuzzy) peer group members to smooth out Gaussian noise.

Trilateral filter [6] has been proposed by adding another weight vector in bilateral filter based on the road statistics, and hence suitable for removing impulse noise also.

The Fuzzy Vector Median Filter (FVMF) [5] performs a weighted averaging where the weight of each pixel is computed according to its fuzzy similarity [3] to the robust vector median.

A simple Fuzzy method for removing mixed Gaussian–impulsive noise is proposed by Joan-Gerard Camarena et.al. [11]. This method also works well for

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removing low density of mixed noise but there are so many parameters to adjust for optimum results. Moreover this is slow process because of calculation of fuzzy weights for each pixel through fuzzy inference mechanism using several fuzzy rules.

SBF [10] has been proposed for removing universal noise. It removes mixed noises from gray-scale image very effectively with best results for high density noise. But there is no vector concept in this filter to remove noise from color image. This filter works best for removing impulse component but not so effective for Gaussian component as bilateral filter.

### *A. Limitations of above techniques*

All the techniques proposed in literature for removing mixed noise from image have some drawbacks and limitations which can be summarized as below:

There are some techniques which can remove mixed noise from gray-scale image sufficiently but not adequate for color images.

A few techniques can remove mixed noise from color image but they do not provide results as efficient as provided by noise-specific technique for low density of noise.

Most of the techniques are not suitable for image corrupted with high density of noise i.e. for more than 25% impulse noise introduced.

SBF technique Remove noise from highly corrupted image but there is no vector concept for removing noise from color image.

If SBF is applied on each color plane separately then color blurriness is introduced in image.

## III. PROPOSED TECHNIQUE

In the thesis work a new technique is proposed to improve the performance of mixed noise removal from color image and gray images keeping following aspects in mind:

- To provide high perceptual quality of de-noised image.
- To provide less color blurriness in de-noised image.
- To preserve edges significantly.
- There should be no need of adjustment of parameters before removing different densities of noises.
- Method should be non-iterative and simple.

### *A. Switching bilateral filter (SBF)*

The SBF removes both Gaussian and impulse noise without adding another weighting function [10]. Operation in this method is performed in two stages: detection followed by filtering. For detection the sorted quadrant median vector (SQMV) scheme is proposed, which includes important features such as edge or texture information.

#### 1) SQMV Approach:

In this approach a large window is subdivided into four sub-widows and then medians of the sub-windows are sorted and resultant vector is called as SQMV.

We divide the window into four subwindows with the central pixel as then corner pixel in the four sub-windows as shown in figure.

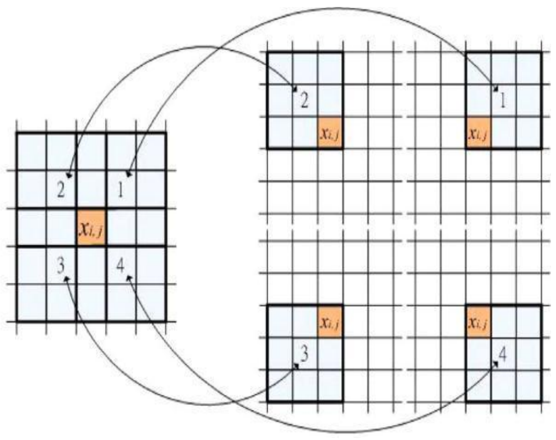


Fig. 3.1 forming of four sub-windows from a large window*

For explanation of the technique, window size is taken as 5 × 5 i.e. we take N=2 , with its four quadrant block of size 3 × 3. Each quadrant block has a median value expressed as

$$m_k = median\{W_k\}, \qquad k = 1\ to\ 4$$

Where m1,m2…mk denotes the median of the top right, top left, bottom left, and bottom right of the four quadrant blocks. These for medians are sorted in an ascending order and SQMV is defined as

$$SQMV = [SQM1, SQM2, SQM3, SQM4]$$

After sorting the medians of the four sub-windows, some of the median values are very similar while others are different, leading to the formation of clusters. The clusters of , and the order of the four medians *m1*, *m2*, *m3*, *m4*, which are mapped into the clusters, include important features of the window such as detail and edges.

### *B. Calculation of SQMR*

The purpose of calculation of reference median SQMR is that a value should denote the property of background i.e. which value is most similar to background in current window. We compare this value with current pixel and decide about noisiness of the pixel. The calculation of SQMR takes the edges in images in account to avoid the false noise detection. In general there are three cases possible in processing window. Out of which first two cases are that current pixel fall on the weak edge or Strong edge. Third case is possible that there are no edges in the current window. These three cases can be identified according the values of medians of the four sub-windows. If value of one median is very different from the value of other three median then it is the case of weak edge. If all the four medians are close to each other then there is no edge in the window. On the other hand if two medians are quite different from other two medians then it the case of presence of strong edge.

On the other hand if there is strong edge in window then one value out of *SQM2* and *SQM3* is taken as reference median. In case of strong Edges there are three possibilities as horizontal edge, vertical edge or diagonal Line/texture. A directional average *DAV* is calculated along the observed edge and then it is used to decide whether *SQM2* or *SQM3* is taken as reference median depending upon which is close to it. The conditions of the edges and then calculation of *DAV* along the edges are calculated as below:

1) ***Horizontal edge:*** In case of horizontal edge *SQM1* and *SQM2* are associated with either {m1, m2} or {m3, m4}. Then horizontal directional average $DAV_H$ is calculated by average of pixels along horizontal edge leaving current pixel as follow:

$$DAV_H = \frac{1}{2N}\sum_{s=-N}^{-1} F_{i+s,j} + \frac{1}{2N}\sum_{s=1}^{N} F_{i+s,j}$$

2) ***Vertical edge:*** When *SQM1* and *SQM2* are associated with either {m1, m4} or {m2, m3}, there is presence of strong vertical edge in window. In this case vertical directional average is calculated as follow:

$$DAV_V = \frac{1}{2N}\sum_{t=-N}^{-1} F_{i,j+t} + \frac{1}{2N}\sum_{t=1}^{N} F_{i,j+t}$$

3) ***Diagonal Line or Texture:*** If both the conditions of horizontal edge or vertical edge are not found but there is a strong edge present in window then this is the case of diagonal edge. This can be expressed as:

$$DAV_D = \frac{1}{4}\left(F_{i-cp,j-cp} + F_{i-cp,j+cp} + F_{i+cp,j+cp} + F_{i+cp,j-cp}\right)$$

Where cp is the index step from current pixel i.e from central pixel of window to central pixel of sub-windows.

In this way calculation of reference median SQMR can be described using following algorithm:

Algorithm for calculation of SQMR

Input: $W_0$, *m1, m2, m3, m4, SQMV*

Procedure:

$SQMD_B = SQM4 - SQM1$

$SQMD_c = SQM3 - SQM2$

If $SQMD_C \le \rho$

$$SQMR = \frac{SQM2 + SQM3}{2}$$

Else

if $\{SQM1, SQM2\} \in \{m1,m2\} \vee \{m3,m4\}$

$DAV = DAV_H$

Else If $\{SQM1, SQM2\} \in \{m1,m4\} \vee \{m2,m3\}$

$DAV = DAV_V$

Else

$DAV = DAV_D$

End if

If $|SQM3 + SQM4 - DAV| \ge |SQM1 + SQM2 - DAV|$

SQMR=SQM2

Else

SQMR=SQM3

End if

End if

Output: SQMR

The same algorithm is applied on the each color plane and in this way three reference median is calculated for each pixel position in color plane. These can be denoted as $SQMR^R$, $SQMR^G$, and $SQMR^B$ for red, green and blue color plane respectively.

### *C. Noise detection*

Detection of noise is a two stage process. In first stage impulse noise is detected and if the current pixel is not found as impulsive noise then Gaussian noise is detected. The noise detector also decides whether a current pixel should be filtered or whether it is noise free. For detection of noise current pixel is compared to Reference median SQMR and on the basis of two threshold noise is detected by following algorithm:

Algorithm for noise detection

Procedure:

Input: $F_x^C$, $SQMR^C$, $Th_1$ and $Th_2$

If ($|F_x^C - SQMR^C| \ge Th_1$)

$SS^C$=1 ($F_x$ is impulse noise)

Else if ($|F_x^C - SQMR^C| \ge Th_2$)

$SS^C$=2 ($F_x$ is Gaussian noise)

Else

$SS^C$=0 ($F_x$ is noise-free)

End

Output: $SS^C$ (Switching Status)

In this algorithm C denotes the color planes. For C=R, G and B the algorithm is applied separately on the color planes and similarly three switching status $SS^R$, $SS^G$, $SS^B$ are obtained for each pixel in color image. These switching statuses are used for switching purpose in the next stage filtering.

## IV. SIMULATION AND RESULTS

### *A. Setup parameters*

Algorithms were developed in MATLAB to simulate the methods for filtering an image consisting of impulse and/or Gaussian noise. MATLAB is used because of large number of advanced inbuilt functions and image processing toolbox. The setup parameters are as shown in table 1.

### *B. Perceptual quality*

By inspection of Fig. 4.1 we can say that proposed technique provides best visual quality of de-noised image**.** Following inferences can be drawn from fig. 4.1.

For image corrupted by slightly density of single noise; the VDF technique provides better quality in case of impulse noise while preserving edges significantly. On the other hand BF provides better quality in case of Gaussian noise.

For image corrupted by higher density of single noise or mixed noise, the proposed technique provides better quality of filtered image with lesser blurriness.

  

| Original Image | 10% impulse | Gaussian with sigma=20 | Mixed of both |
|---|---|---|---|
|  |  |  |  |
| Filtered by VMF |  | | |
| Filtered by VDF |  | | |
| Filtered by PGA |  |  |  |

| Original Image | 10% impulse | Gaussian with sigma=20 | Mixed of both |
|---|---|---|---|
| Filtered by FVMF |  |  |  |
| Filtered by BF | |  |  |
| Filtered by FBF |  |  |  |
| Filtered by TF |  |  |  |
| Filtered by SBF |  |  |  |
| Filtered by proposed technique |  |  |  |

Fig. 4.1: Comparison of Perceptual Quality of De-noised Image

### *C. PSNR*

PSNR, MSE, MAE and NCD are compared for all the techniques for Gaussian Noise, Impulse noise separately in Table 5.2 and 5.3 respectively.

When noisy image have only Gaussian noise, bilateral filter provide best results for low density of noise i.e. for less value of standard deviation while proposed technique provide best results for highly corrupted image. This is due to the fact that with large variance some pixels become impulsive.

For noisy image having impulse noise only, the SBF provides approximately same results with the MDB technique however it provides slightly better PSNR for highly corrupted noisy image.

Table 1: Setup Parameters

| | |
|---|---|
| Image | 256*256*3 (color) |
| Image type | Bmp |
| Impulse Noise | 5%, 10%, 15%, 20%, 25% |
| Gaussian Noise | Standard deviation (sigma)= 10, 20, 30, 40, 50 |
| Mixed Noise | impulse + Gaussian |
| Simulation Tool | MATLAB 7.13.0.564 |
| Processor | Core-i3 @2.53 Ghz RAM 3GB |

### *D. NCD*

It is used to measure the blurriness in colors of image during filtering process according to human perception. For better color quality of filtered image NCD should be very less. For removing single noise the NCD are given in table 5.2 and 5.3 respectively for Gaussian noise and impulse noise while for removing mixed noise the proposed technique is compared in table 5.7. The graphical comparisons of all the techniques are shown in Fig. 5.5. The following inferences can be drawn by analyzing the mention tables and figures:

1) For removal of impulse noise VDF technique provides lesser NCD for lower percentage of impulse noise i.e. less than 15% while for higher density proposed technique provide lesser NCD.
2) For removal of Gaussian noise and mixed noise the proposed technique provide best results in terms of NCD values.

## V. CONCLUSION

In this thesis work we studied several techniques for removing mixed noise where mixed noise is considered as mixture of Gaussian noise and impulse noise. Some of the techniques are implemented in the work and analyzed in terms of various performance matrices. By understanding advantages, drawbacks and limitation of these techniques, we proposed an optimum technique for removing mixed noise from color image. We proposed a SBF technique for this purpose. The proposed will certainly have higher time complexity in comparison to the pure MBD technique but at the same time gives several advantages as follows:

1) Proposed technique provide best perceptual quality by smoothen image and reducing the color blurriness.
2) For higher noises whether single or mixed no other techniques provide better results as ours.
3) The SBF works very well for higher dense noise and does not introduces blurriness as in case of Bilateral filter.

## REFRENCES

[1] Y. Deng, C. Kenney, M. S. Moore, and B. S. Manjunath, ―Peer group filtering and perceptutal color image quantization,‖ in Proceeding of IEEE International Symposium on Circuits and Systems (ISCAS), vol. 4, pp. 21–24, 1999 .

[2] K.E. Barner, Y. Nie, and W. An, ―Fuzzy Ordering Theory and Its Use in Filter Generalization,

EURASIP Journal of Applied Signal Processing, vol. 2001, pp. 206-218, Dec. 2001.

[3] H. L. Eng and K. K. Ma, ―Noise adaptive soft-switching median filter, IEEE Transactions on Image Processing, vol. 10, no. 2, pp. 242–251, Feb. 2001.

[4] Y. Shen, K.E. Barner, ―Fuzzy Vector Median Based Surface Smoothing‖, IEEE Transactions on Visualization and Computer Graphics,

  

vol. 10 no.3, pp. 252-265, May-June 2004.

[5] P. Scheunders, ―Wavelet thresholding of multivalued images,‖ IEEE Transactions on Image Processing, vol. 13, no. 4, pp. 475–483, Apr. 2004.

[6] D. Tschumperl´e, R. Deriche, ―Vector-valued image regularization with PDEs: A Common framework from different applications‖, IEEE transactions on pattern analysis and machine intelligence, vol. 27 no. 4, pp. 506-517, April 2005.

[7] S. Schulte, B. Huysmans, A. Pizurica, E. E. Kerre, and W. Philips, ―A new fuzzy-based wavelet shrinkage image denoising technique,‖ in Proceeding of Advanced Concepts for Intelligent Vision Systems, vol. 1, pp. 12–23, 2006.

[8] S. Schulte, B. Huysmans, A. Pizurica, E. E. Kerre, and W. Philips, ―A new fuzzy-based wavelet shrinkage image denoising technique,‖ in Proceeding of Advanced Concepts for Intelligent Vision Systems, vol. 1, pp. 12–23,2006.

[9] S. Morillas, V. Gregori, A. Herv´as, ―Fuzzy peer groups for reducing mixed Gaussian impulse noise from color images‖, IEEE Transactions on Image Processing, vol. 18 no. 7, pp. 1452-1466, Jul. 2009.

[10] C.H. Lin, J.S. Tsai, C.T. Chiu, ―Switching bilateral filter with texture/noise detector for universal noise removal‖, IEEE Transactions on Image Processing, vol. 19 no. 8, pp. 2307-2320, Sep. 2010.

[11] Joan-Gerard Camarena, Valent´ın Gregori, Samuel Morillas and Almanzor Sapena "A simple fuzzy method to remove mixed Gaussian-impulsive noise from colour images" in IEEE transactions on fuzzy systems, vol. PP, No. 99, Dec. 2012.

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