High Density Noise Suppression Using Modified Weighted Average Filtering

R.Gayathri, D.P Sangeetha, Uday Bikram Yadav

***Abstract:** In this paper, High density noise is suppressed by using Modified weighted Average Filter. The new method suppresses noise in two steps. At first, all the corrupted pixels are detected by using impulse detection, and this corrupted pixels are applied for image correction, where distance transform and index array is computed, which contains the linear index of the nearest non zero pixels of noisy pixels and distance, this index array also contain closest pixel map(CPM),and initial image is obtain from bilinear interpolation and applied to weighted average filter, where new weight are recalibrate by replacing noisy pixels with new intensity values. Simulation results shows that the output of Weighted Average Filter provides better image visual quality with low PSNR value.*

***Index Terms**: Average Filtered, CPM, impulse detection, image correction, initial image, index array, Weighted Average Filter*

I. INTRODUCTION

Noise suppression is the procedure where noise is identified from the image by using different technique and filter available in the present day. Although this technique not only help to identify noisy pixels present in any particular image but it also help to enhance the quality of the image. Noise is introduced in any image while transmitting and receiving an image through communication channel this will change not only position but it also change the intensity of an image. In many case, it also change the dimension of the an image as well as the edge of an image. In any image, noise is introduced in the form of impulse (i.e. SPN, Gaussian noise etc.) where white and black are randomly distributed in any grey scale image, if any pixel introduce in black pixels distribution or in white pixels distribution it is consider as a noise. The black pixels and the white pixels are represented by 0 and 255. Impulse noise model is defined as follows.

$$\tilde{z}_{i,j} = \begin{cases} M_{max} & \text{with probability} \quad r/2 \\ z_{i,j} & \text{with probability} \quad 1-r \\ M_{min} & \text{with probability} \quad r/2 \end{cases} \tag{1}$$

Where M_{max} and M_{min} define the maximum and minimum impulse value having same probability noise density, $\tilde{z}_{i,j}$ and $z_{i,j}$ represent corrupted & original image.

The remaining section is define in four section i.e. Section II define The New Method ,Section III define The image quality evaluation factor, Section IV define simulation result and section V define conclusion.

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II. THE NEW METHOD

Noise suppression by using new method is done in two steps namely Impulse Detection and Image Correction.
Each steps are explained below.

A. Impulse Detection

Impulse detection is done by marking all the pixel with impulse value M_{min} and M_{max} . Although we know that, the two distinct pixels have more information than the pixels lies in its vicinity. So, the corrupted pixels are identified by taking correlation between suspicious pixels and original pixels which is inclined with the one of these impulse value with equal probability.

Impulse detection algorithms are described below:

Steps 1: Initially specify the two impulse value M_{min} and M_{max} from the corrupted image, and calculate Ω_M .

$$\Omega_M = \{(i, j) \mid (\tilde{z}_{i,j} = M_{min}) \vee (\tilde{z}_{i,j} = M_{max})\} \tag{2}$$

Where Ω_M indicates the suspicious pixels which consist of one of the impulse value and the symbol ∨ denotes logical OR.

Steps 2: Estimate the noisy probability $\tilde{r}$ as a suspicious pixels and set window W as $\sqrt{1+\frac{5}{1-\tilde{r}}}$.

Where W is odd integer greater than the specified value.

Steps 3: Calculate the number of pixel $e_{i,j}^{min}$ & $e_{i,j}^{max}$ at co-ordinate (i, j) which has grey value M_{min} and M_{max} respectively.

Steps 4: Again, calculate Ω_{b1} and Ω_{b2} as follows.

$$\Omega_{b1} = \{(i, j) \mid e_{i,j}^{min} + e_{i,j}^{max} = \omega_d^2\} \tag{3}$$

$$\Omega_{b2} = \{(i, j) \mid (\tilde{z}_{i,j} = M_{min}) \wedge (e_{i,j}^{max} < \frac{e_{i,j}^{min}}{3}) \vee ((\tilde{z}_{i,j} = M_{max}) \wedge (e_{i,j}^{min} < \frac{e_{i,j}^{max}}{3}))\} \tag{4}$$

Where the ∧ and ∨ symbols denotes logical AND & logical OR.

Steps 5: Construct Ω_{b1} and Ω_{b2} as follows:

$$\Omega = \Omega_M \cap (\overline{\Omega_{b1}} \cup \overline{\Omega_{b2}}) \tag{5}$$

Where ∪ and ∩ denotes the union & intersection operators, $\overline{B}$ denotes the complement of B.

In the above equation, symbol Ω_{b1}, Ω_{b2}, Ω suggest that all of its neighbor have equal impulse values and it inclined to one of this impulse value.

Here, Mask is defined as:

$$\text{mask} = \begin{cases} 0 & \text{if } (i,j) \in \Omega \\ 1 & \text{if } (i,j) \in \Omega \end{cases}$$

(6)

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Where Ω define the set of corrupted pixels.

B. Image Correction

Image correction is done by using Weighted-Average Filtered. In our proposed model initial image is constructed from bilinear interpolation. This initial image is subjected to weighted-average filter.

1. Known Pixels Weight

Pixels are randomly distributed in any image which suggests that distinct pixels have more information than the two closest pixels. This suggests that by correcting the noisy pixels better quality of image can be achieved. Each pixel consist of unique information and the information matrix is given as:

$$I_M = \frac{1}{mask * k} \quad (7)$$

Where k is the convolution kernel, * denotes the convolution operator, size of the matrix is 3 x 3 . Therefore weight of known pixels is given as :

$$W_{known} = 9 * I_M \quad (8)$$

2. Noisy Pixels Weight

Weight of the noisy pixels is calculated according to the image property. For the noisy image, pixels which was away from the closest pixel have smaller correlation and gives less accurate values.

Distance Transform is calculated from the corrupted pixels which consist of Distance Matrix (DM) and Closest Pixels Mask. Distance matrix and closest pixels mask contain city block distance metrics measures the path between the pixels based on a four connected neighborhood pixels whose edge touch are 1 unit apart;

Pixels diagonally touched are 2 units apart and Noisy pixels weight is represented as:

$$W_{noisy} = \frac{1}{1+D} \quad (9)$$

Where D is the distance matrix and equation (6) implies that weight of noisy pixels is directly proportional to inverse of distance matrix and the range of the distance matrix is in the range of (0, 1/2]. In our proposed filter, Bilinear Interpolation is used to reduce the de-blurring effect so as the visual quality of image is increased. Algorithms for the image correction are described below:

Steps 1: Compute the Distance Matrix (D) and Closest Pixel Map (CPM) from the corrupted image z̃.

Steps 2: Initially, Initial image (*int)* is calculated by taking interpolation of the closest pixel map of the index array.

Steps 3: Compute the total weight matrix.

$$W_m = mask \,.\, W_{known} + (1-mask) \,. \quad (10)$$

Steps 4: Output of Weighted Average Filter is

$$Out = \frac{(z^{int} * W_m)k}{W_m * k} \quad (11)$$

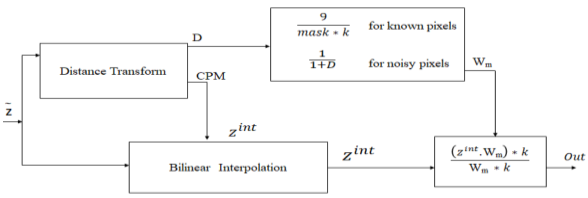
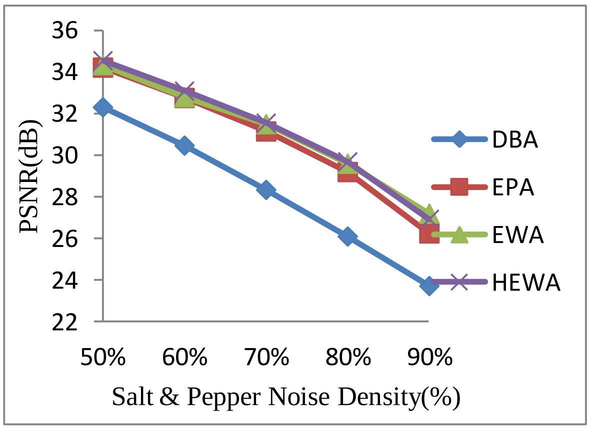
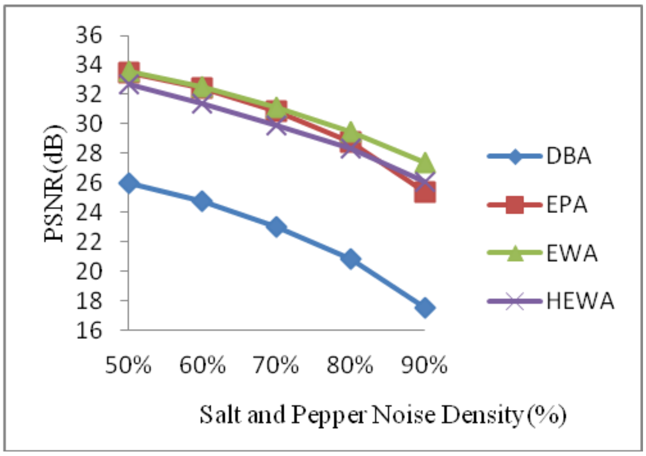


Fig. a: The New Method for Image Correction



(1) Lena Image



(2) Pepper Image

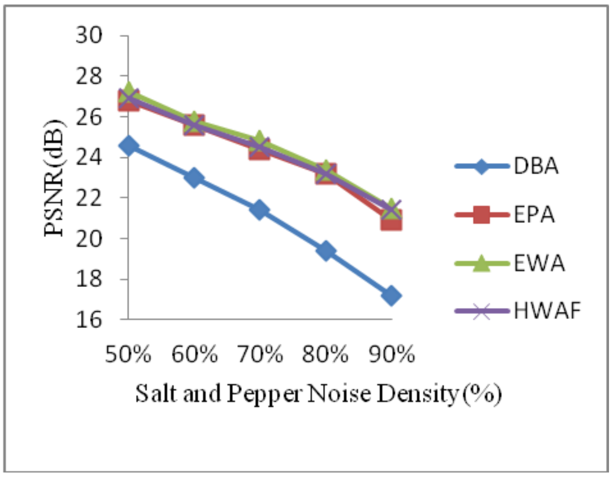


Fig. (3) Bridge

Fig. b: Graphical representation of image in terms of PSNR (dB) and Noise density.

III. THE IMAGE QUALITY EVALUATION FACTOR

A. PSNR :

PSNR is the abbreviation of peak signal to noise ratio which is define as maximum power of signal to the power of noise. Mathematically, It is expressed as

$$\text{PSNR} = 10 \log_{10} \frac{255^2}{MSE} \quad (12)$$

Where the term MSE stand for mean square error which identify error between original image and noisy image and Mean Square Error is defined as

$$\text{MSE} = \frac{i,j[\,I_1(i,j) - I_2(i,j)]^2}{i,j} \quad (13)$$

Where i and j represents the numbers of rows and columns.

B. Similarity Measurement Indicator (SMI)

Similarity measurement indicator is image quality evaluation indicator which measure the similarity between noisy image and original image. Mathematically it is expressed as

$$\text{SMI (P, Q)} = \frac{1}{W}\sum_{i=1}^{W} \text{SSIM}\,(p_i,\ q_i) \quad (14)$$

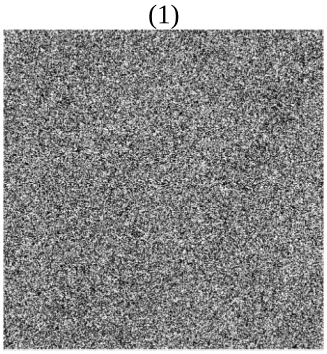
Where p_i & q_i are reference image and resolution enhanced image respectively and W is the number of windows present in the image[5].Structural similarity index is reference matrix which measures the image quality based on a reference image. Mathematically

$$\text{SSIM}\,(p, q) = \frac{(2\mu_p + D_1)(2\sigma_{pq} + D_2)}{(\mu_p^2 + \mu_q^2 + D_2)(\sigma_p^2 + \sigma_q^2 + D_2)} \quad (15)$$

Where μ_p, μ_q, σ_{pq}, σ_p and σ_q represents the mean, cross-covariance and standard deviation of images P and Q local means, standard deviations, Also, D1, D2 are Column vector [5].

Original Noisy Filtered Output Image

(1)

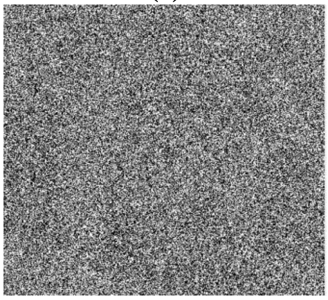


(2)

(3)

Fig. C: Lena image with HWAF: (1) Original image, (2) Lena image at 90% S&P noise, (3) Filtered image of (1)

(4)



(5)

(6)

Fig. D: Pepper image with HWAF: (4) Original image, (5) Pepper image at 90% S&P noise, (6) Filtered image of (4)

(7)

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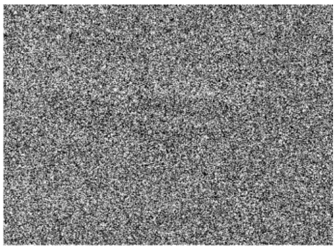

(8)

(9)

Fig. E: Bridge mage with HWAF: (7) Original image, (8) Bridge image at 90% S&P noise, (9) Filtered image of (7)

IV. SIMULATION RESULT

In our proposed method, Lena, peppers and bridge is taken as a test image of size 512× 512. In each image different noise density is added to the image and subjected to the weighted average filter, where after getting an output, SSIM value is measured and obtain 26.93 db. at 90% noise density for Lena image which was shown in fig.(a) . For pepper image, PSNR value for 90% noise density is found to be 21.3835db which was shown in fig. (b). similarly, for bridge image PSNR value for 90% noise density is found to be 21.3835dB**.** In this paper each simulation is run several times by taking several image and while executing it is found that execution time may vary by a decimal number which depend upon the processor type and type of application running on the PC. All the simulation is performed by using MATLAB tool**.**

V. CONCLUSION

In our new method, By applying different noise density to test image of size 512×512 and it seems that at 90% noise density the peak signal to noise ratio value is higher than the existing method. For the Lena image and for the pepper and ridge image peak signal to noise ratio value is lower .The Computational time for this method is vary according to the noise density and processing time of CPU. After checking the SSIM value of different image we came in conclusion that new method gives best result in terms of peak signal to noise ratio value for both color image and grey scale image.

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