An Efficient Additive White Median Filtering for Removal of Salt and Pepper Noise based on Images

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ABSTRACT
Several researchers are concentrated on cancellation of salt and pepper noise from the two-dimensional signals like digital images and uses several filters like mean filter, median filter, trimmed median filter etc., for removal of noise. A novel approach has been implemented using a filter so called Additive White Median Filter (AWMF) for filtering the two-dimensional signal which uses a schematic procedure where mean value of the particular window size is used instead of median value for the removal of high density noise from the signals without changing the clarity of the digital image. In this scheme noisy pixels are replaced with the neighborhood non noisy pixels mean value. Whenever the window selected dynamically is non-flexible with the corrupted pixels, then the size of the window is increased in order to flexible with pixels. The selection of window size depends on the noise density in the image and also corrupted pixel density in the window. Hence a variable window size is chosen for the removal of noise in the pixels. The novel scheme is subjected to various aspects of the two-dimensional signal and also for different noise levels in order to evaluate the performance. Comparative studies proves that the novel scheme removes the salt and pepper noise effectively with better image quality compared with conventional methods and recently proposed methods such mean filter, modified decision based un-symmetric trimmed median filter, median filter and adaptive median filter. The simulation results shown in the below sections and from which it is clear that the newly defined novel approach has removed salt and pepper noise better than all the conventional methods for variable noise levels and also it removes noise without losing the edge information.

Keywords
Additive White Median Filter, Salt and Pepper Noise, Mean Filter, Median Filter, Modified Decision Based Unsymmetrical Median Filter.

1. INTRODUCTION
Signal is defined as conveying some amount of information or it is also defined as function of one or more independent variables.

Signal with one independent variable is called as one dimensional signal examples of one dimensional signal are speech signal, noise signal etc.

Signal with two independent variables is called as two dimensional signal examples of two dimensional signals are digital images.

Signal with three independent variables is called as three dimensional signals; video signal is the example of three dimensional signals.

An image is also defined as group of pixels and depending upon the number of bits images are classified into binary image, gray image and color image.

A binary image consists of either 0 or 1 as pixel value. It is also called as black and white image. 0 refers to black and 1 refers to white.

A gray image consists of any of the 8 bits in their pixel values. The quality and quantity of an image can be modified when it is in gray format only.

A color image consists of three regions namely red, green and blue (RGB) and each region consists of 8 bits, hence there should be 24 bits in their pixel values.

2. OBJECTIVE
The main objective of this paper is to reduce the background noise i.e., salt and pepper noise that is inherently present in the two dimensional signal i.e., image by using a novel technique.

3. IMAGE ENHACEMENT
Enhancement refers to improving the quality in both subjective and objective aspects.

Coming to enhancement in images, it increases the brightness or intensity of the images by using several techniques and also the removes the noise in the noisy pixels.

4. NOISE
Noise is an unwanted data present within the desired data. Removal of noise from the signals is also one of the properties of enhancing technique. Noise is of several types namely random noise, white noise, impulse noise etc.

4.1 Salt and Pepper Noise
Especially in images salt and pepper noise plays a key role. Removal of salt and pepper noise draws researcher's attention from several decades. Different filters are proposed to remove this type of noise and each and every one of them satisfies several performance criteria's. Fig 1 shows the color image, black and white image and noise image corrupted by salt and pepper noise.

The novel approach also proposed to remove this salt and pepper noise where the intensity of noise is high and also to increase the performance of image by increasing PSNR, decreasing MSE etc.

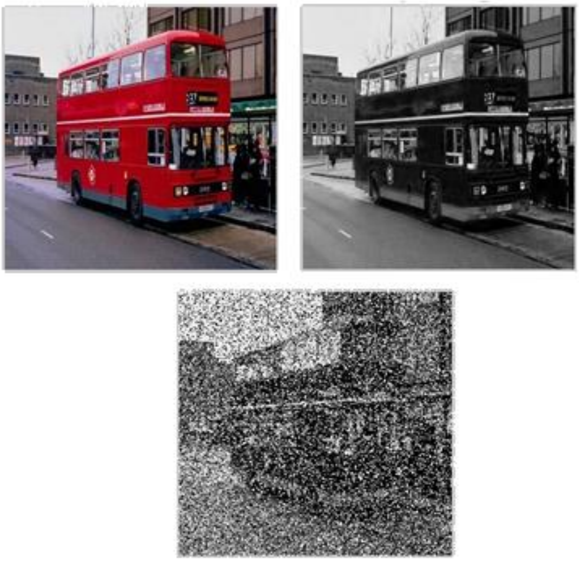


Fig 1: The process of adding salt and pepper noise to the color image

5. PREVIOUS WORK

Several methods are proposed earlier in order to remove salt and pepper noise from the images and these techniques provide several advantages from one another in different aspects of images. Out of these some of the techniques are described in the following sub sections [1].

5.1 Mean Filter

Mean filter is the filter which denoises the noisy pixels through checking the similarity of the each pixel in the selected window with the all the pixels as shown in fig 2.

First, it selects the noisy pixel form the image after that a window is selected and put that window on the noisy pixel, which should be at the center of the window. After that the mean value of the input matrix is determined. And this intensity value is replaced with the noisy pixel value. At each and every step it checks whether it is a last window or not. If it was last window then the iteration ends or else then again the new window is selected and after that mean value is determined all these steps are continued until the last window is reached [7].

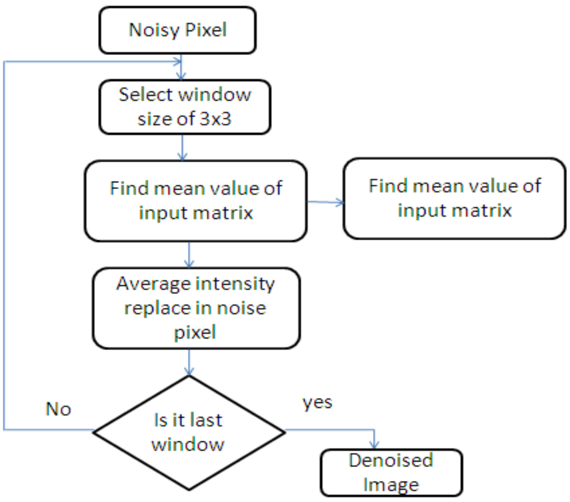


Fig 2: Flow Chart of Mean Filter

5.2 Median Filter

Median filter is one of the non linear filters, which removes the noise from the noisy pixels by using iterative steps [5].

Noise cancellation is the wing which was attained several researchers' attention from decades. Median filter removes the noise with edge preservation. Noise cancellation is the one of the image enhancing technique used in the median filtering.

125	135	146	152	178
152	**10**	**125**	**145**	145
135	**149**	**146**	**152**	146
184	**95**	**86**	**75**	254
98	54	32	21	125

10;125;145;149;146;152;95;86;75 MEDIAN VALUE:110

Table 1: Median Value Calculation Process

The iterative steps used in this filtering approach are as follows [2].

First it selects the noisy pixel in the image, after that it selects the window of size 3X3, then the weighted value of the corrupted pixel is determined.

Finally it replaces the noisy pixel with the weighted median value and now it checks for whether the window is last one or not. Fig 4 shows the flow chart of median filter.

If it was last window then the iteration ends otherwise the same procedure is continued until the last window is encountered [6].

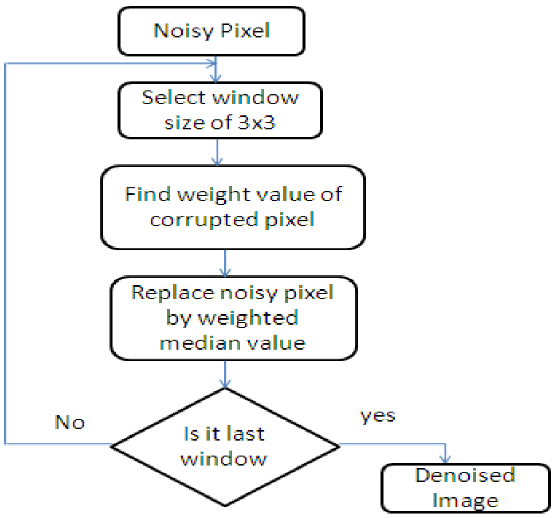
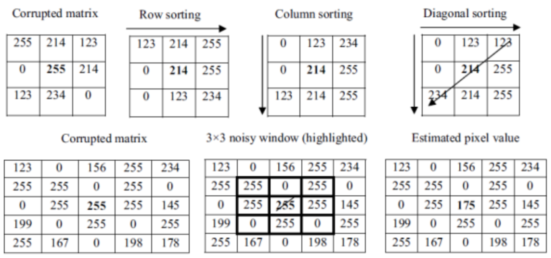


Fig 4: Flow Chart of Median Filter

If there is odd number of entries in the window then it is easy to implement. It is also referred as the middle value of the all entries within the window after sorting.

5.3 Decision based Algorithm

In this approach median filter of adequate window size is employed in favor of finding corrupted element. Absolutely the distinction among the element of interest and therefore the median filtered output is obtained as well as compared with the edge obtained from the minimum and most element values within the chosen window [3]. Hence the corrupted pixels value is one and the uncorrupted pixels value is zero for the image using binary flag is obtained. The corrupted element values are calculable in the support of novel values exploitation the median/mean filtering. The corrupted pixels are obtained when the binary flag image *b* (*i,j*) is 1. These pixels are replaced by the new estimated pixel value using median filter for lesser noise densities or mean filter for higher noise densities as shown in fig 5 [10].



(123+156+234+145+199+167+198+178)/8=175, the corrupted pixel value is replaced by 175. (Case 3)

Fig 5: Decision Based Algorithm Process

To find the estimate, let the observed pixel be represented as $y(i,j)$ and the number of corrupted pixels in the window $W_{x(i,j)}$ be "*n*." For illustration purpose, let's assume that the corrupted pixels take values, x_{max} = 255 and x_{min} = 0. The pixels may also take other values in the intensity range [0,255].

Case 1: If the number of corrupted pixels "*n*" in the window $W_{x(i,j)}$ is less than or equal to 4, that is, *n* _ 4, then two dimensional window of size 3×3 is selected and median operation is performed by row sorting, column sorting, and diagonal sorting. The corrupted pixel value *y*(*i,j*) (highlighted) is replaced by the median value.

Case 2: If the number of corrupted pixels "*n*" in the window $W_{x(i,j)}$ is between 5 and 12, that is, 5 _ *n* _ 12, then 5×5 median filtering is performed and the corrupted values are replaced by the median value.

Case 3: If the number of corrupted pixels "n" in the window $W_{x(i,j)}$ is greater than 13, that is, n _ 13 increasing the window size leads to blurring, even with smaller window sizes, the output may happen to be noise pixels whenever the noise is excessive. In this case, the average of uncorrupted pixels in the window is found and the corrupted value is replaced by the average value instead of median value.

5.4 Modified Decision based Unsymmetric Trimmed Median Filter

To update the decision based algorithm one should go with the novel algorithm called as modified decision based un-symmetric trimmed median filter (MDBUTMF). In this process an iteration steps fused to remove noise from the noise pixels is as follows [4].

Step 1: Select 2-D window of size 3X3. Assume that the pixel being processed is.

0	**255**	**0**
0	**255**	**255**
255	**0**	**255**

Table: 2 (a) Modified Decision Based Filter Process

Where 255 is processing pixel P(i,j)

Step 2: If then is an uncorrupted pixel and its value is left unchanged. This is illustrated in Case iii) of Section IV.

Step 3: If or then is a corrupted pixel then two cases are possible as given in Case i) and ii).

Case i): If the selected window contains all the elements as 0's and 255's. Then replace with the mean of the element of window.

Case ii): If the selected window contains not all elements as 0's and 255's. Then eliminate 255's and 0's and find the median value of the remaining elements. Replace with the median value [8].

Step 4: Repeat steps 1 to 3 until all the pixels in the entire image are processed.

Case(i): If the selected window contains salt/pepper noise as processing pixel (i.e., 255/0 pixel value) and neighboring pixel values contains all pixels that adds salt and pepper noise to the image:

Since all the elements surrounding are 0's and 255's. If one takes the median value it will be either 0 or 255 which is again noisy. To solve this problem, the mean of the selected window is found and the processing pixel is replaced by the mean value. Here the mean value is 170. Replace the processing pixel by 170.

Case(ii): If the selected window contains salt or pepper noise as processing pixel (i.e., 255/0 pixel value) and neighboring pixel values contains some pixels that adds salt (i.e., 255 pixel value) and pepper noise to the image:

Where 0 is processing pixel P(i,j)

78	**90**	**0**
120	**0**	**255**
97	**255**	**73**

Table: 2 (b) Modified Decision Based Filter

Now eliminate the salt and pepper noise from the selected window. That is, elimination of 0's and 255's. The 1-D array of the above matrix is [78 90 0 120 0 255 97 255 73]. After elimination of 0's and 255's the pixel values in the selected window will be [78 90 120 97 73]. Here the median value is 90. Hence replace the processing pixel by 90.

90	**95**	**90**
45	**65**	**21**
32	**90**	**101**

Table: 2 (c) Modified Decision Based Filter

Case (iii): If the selected window contains a noise free pixel as a processing pixel, it does not require further processing. For example, if the processing pixel is 90 then it is noise free pixel: Since "90" is a noise free pixel it does not require further processing.

Each and every pixel of the image is checked for the presence of salt and pepper noise. Different cases are illustrated in this Section [9].

If the processing pixel is noisy and all other pixel values are either 0's or 255's is illustrated in Case (i).

If the processing pixel is noisy pixel that is 0 or 255 is illustrated in Case (ii).

If the processing pixel is not noisy pixel and its value lies between 0 and 255 is illustrated in Case (iii).

6. PROBLEM STATEMENT

Noise is unwanted data that to be removed from the past analysis. Several techniques has been designed and implemented to remove this unwanted data. Mean filter, median filter, decision based algorithm, modified decision based unsymmetric trimmed median filter are used to remove the noise, these are some of the filters designed to remove the noise and each method provides several advantages like low mse, high snr e.t.c. Hene the main task of this paper to remove the noise data from the 2dimensional noisy signal.

7. ADDITIVE WHITE MEDIAN FILTER

The novelty of the projected additive white median filtering (AWMF) theme is that it uses norm of dynamic window size rather than norm for filtering of high density clattering pictures while not blurring. This filter replaces the clattering pixels with the norm of non-noisy neighbouring pixels selected from a window dynamically. If the quantity of non-noisy pixels within the selected window isn't spare, a window of next higher size is chosen. This entire process is shown in the below fig 7.

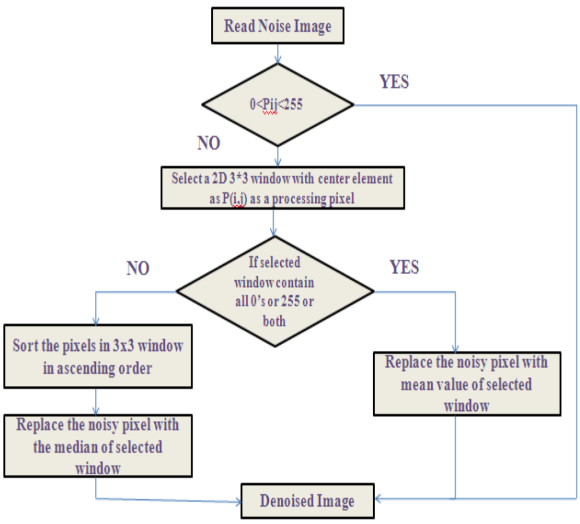


Fig 7: Flow Chart of Additive White Median Filter

Thus window size is mechanically tailored supported the density of noise within the image additionally because the density of corruption native to a window. As a result window size could vary element to element whereas filtering.

The affectivity of the projected theme is evaluated with reference to subjective additionally as objective parameters on normal pictures on numerous noise densities.

8. RESULT ANALYSIS

The figure 8 shows that additive white median filter removes noise better than other existing methods which can be decided by evaluating the parameters like Signal to Noise Ratio, Mean Square Error and Image Enhancement Factor. Signal to noise ratio is the objective factor that improves the signal presence in the output image. Signal to noise ratio is the factor which decides the quantity of the signal present at the output image after filtering process is completed. More signal to noise ratio mean more signal present at the final image after filtering.

Fig 8: Result of Additive White Median Filter

Mean Square Error is the factor which decides the quality of the signal present at the output. Mean square error value is evaluated at each pixel value in order to provide how much correction is applied to that pixel to increase the quality of the signal by removing the noise present in that signal.

Peak Signal to Noise Ratio is shown in figure 9 is evaluated by using the equation as follows.

$$PSNR = 10\log_{10}[\frac{(255 * 255)}{RMSE}]$$

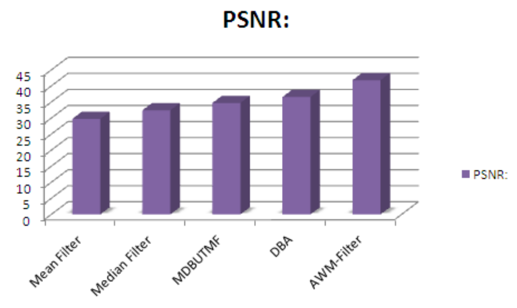


Fig 9: Comparison of PSNR values of different filters

Mean Square Error is the error value which should be low as possible for getting better performance. MSE shown in the figure 10 is evaluated using the equation as follows.

$$MSE = \frac{\{\sum\sum[K(i,j) - P(i,j)]^2\}}{MXN}$$

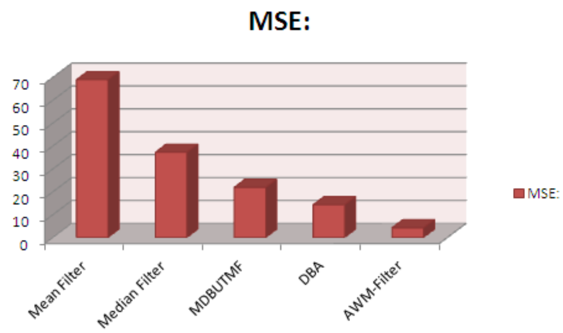


Fig 10: Comparison of MSE values of different filters

With help of image enhancement factor the improved enhancement results are obtained. IEF shown in figure 11 are calculated according to the following formulae.

$$IEF = \frac{\{\sum\sum[Q(i,j) - P(i,j)]^2\}}{\{\sum\sum[K(i,j) - P(i,j)]^2\}}$$

IEF:

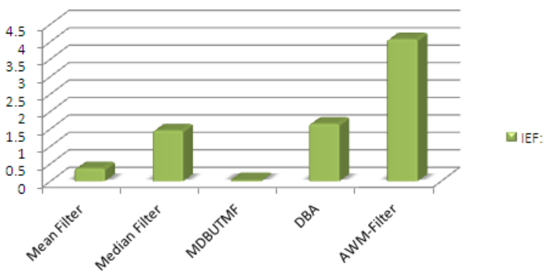


Fig 11: Comparison of IEF values of different filters

SNR is the Signal to noise ratio which decides the percentage of signal obtained at the output of the filter. Figure 12 shows the comparison of different filters SNR by using the formula shown below.

$$snr\ power = 10\log_{10}\left(\frac{signal\ power}{noise\ power}\right)$$

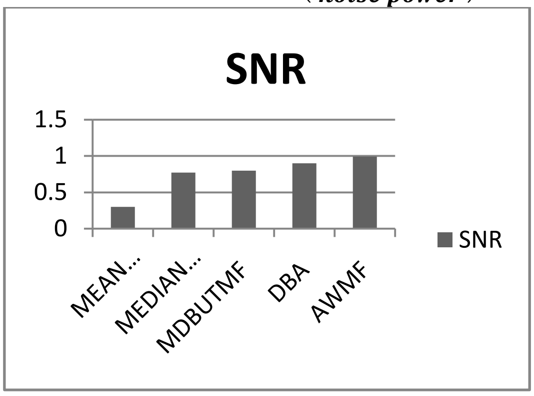


Fig 12: Comparison of SNR values of different filters

	Mean Filter	Median Filter	MDBUT MF	DBA	AWMF
MSE	68.9713	37.2462	21.9475	14.333	4.2812
SNR	0.3013	0.7700	14.1926	0.9022	0.9937
IEF	0.3682	1.4535	1.5003	1.6442	4.0693
PSNR	29.7441	32.42	34.717	35.5673	41.8152

Table 3: Comparison of different types of filters in several areas like MSE, SNR, PSNR and IEF

9. CONCLUSION

Form the result analysis the newly proposed novel scheme provides performance which is better than any other noise removal algorithms in the aspects of PSNR, MSE and IEF. The simulation results are performed for different noise levels and for different types of noises for color and gray images. The proposed additive white median filter (AWMF) removes noise also at high noise level better than other methods. Hence in order to increase the Peak Signal to Noise Ratio, Image Enhancement Factor and to decrease the Mean Square Error as shown in the above figures, one should prefer the additive white median filter at any noise levels and also the operation is performed for different images like 8 bit gray image and 24 bit color image.

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