ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

# Adaptive Median Filter for Image Enhancement

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***Abstract— Median filters can be used to reduce impulse noise level from corrupted images. Median filters are used to remove the salt-and-pepper noise. The median filter is a simpler nonlinear smoothing operation that takes a median value of the data inside a moving window of finite length. Median filter can be used to evaluate the averaging value of filter*. A methodology based on median filter for the removal of salt and pepper noise by its detection followed by filtering in binary images has been proposed in this paper. The, filter such as adaptive median filter is derived. The signal suppressed and signal dependent centre weighted median filter which is a weighted median filter giving more weight to central value of each filter. Adaptive centre weighted median filter and adaptive centre weighted average median filter is implemented and results are compared on the basis of performance analysis.**

***Index Terms*—SAM, Image Filtering, Adaptive Median Filter.**

## I. INTRODUCTION

Median filter is a hybrid of adaptive median filter and switching median filter. Adaptive median filter is use to enable the flexibility of the filter to change its size accordingly based on the approximation of local noise density. The adaptive median filter is based on a trans-conductance comparator, in which saturation current can be modified to act as a local weight operator. Switching median filter is used to speed up the process, because only the noise pixels are filtered. Median filtering preserves edges in images and is particularly effective in suppressing impulsive noise. The application of adaptive median filter is communication, radar, sonar, signal processing, interference cancellation, active noise control, biomedical engineering. Median filter is one of the popular methods to be employed to reduce impulse noise level from corrupted images. The conventional median filter does not have the ability to differentiate between noise free and noisy pixels. The median filter performs quite well, but it falters when the probability of impulse noise occurrence becomes high, To overcome this situation we propose a new algorithm for adaptive median filters with variable window size. This filter is to be robust in removing mixed impulses with high probability of occurrence while preserving sharpness.

Three new methods based on SAM, Circular SAM(CSAM),Weighted SAM(WSAM),Weighted CSAM(WCSDAM).The switching median(SM) filters is more effective than uniformly applied methods, in which a median and weighted median (WM) filter is usually used to detect impulses. However, the median based detector fails to distinguish thin lines from impulses. The basic operation involves two processes,

1) A Filtering process: In which produces an output signal in response to a given input signal.

2) Adaptation Process: In which aims to adjust the filter parameters (filter transfer function) to the (possibly time varying) environment. Separable 2-D median filter preserves 2-D edges.

## II. IMAGE FILTERING

Image filtering [2] consists of basically two stages one is noise detection & second is noise cancellation as described below:

**Stage 1: Noise Detection:** This stage is needed to identify the "noise pixel" candidates from an image of size M*N pixels. It is known that for an image with L intensity levels, the pixels corrupted by the impulse noise are usually digitised into either the minimum or the maximum values of the dynamic range(i. e 0 or L-1).Therefore, at each pixel location (x, y),we can mask alpha by using the following equation:

$$\alpha(x,y)=\begin{cases}1 & : \quad f(x,y)=0 \text{ or } L-1 \\ 0 & : \quad \text{otherwise}\end{cases} \tag{1}$$

Where f is the input image, and the value 1 and 0 represent the "noisy pixel" and "noise free pixel".

**Stage 2: Noise Cancellation:** In this stage, the output image g is obtained by using the switching median filter framework as defined by,

$$g(x,y)=\begin{cases}f(x,y) & : \quad \alpha(x,y)=0 \\ m(x,y) & : \quad \text{otherwise}\end{cases} \tag{2}$$

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
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Where m is the median value obtained from our adaptive method. The implementation of SAM filter, CSAM filter, WSAM filter, WCSAM filter is as shown in fig.

## III. ADAPTIVE MEDIAN FILTER

### *A. CWM FILTER:*

Let X (.,.) and Y(.,.) be the input and output respectively, of the median filter.

$$\mathbf{Y\ (i\ ,j)=median}\{X(i-s,j-t)\,|\,(s,t)\epsilon W\} \qquad (3)$$

Here W is the window that is defined in terms of image co-ordinates in the neighbourhood of the origin. The total number of points in a window is called window size. It is assumed that W includes the origin (0,0) and its symmetric with respect to the origin i.e (s, t)ЄW implies (-s ,t)ЄW,(s,-t)Є W,(-s,-t)ЄW .For such a window an odd window size is guaranteed, and sample median of pixels inside the window is selected. Throughout the window size is denoted by 2L+1.

Consider the WM filters with weights,

$$\{h(s,t)\,|\,(s,t)\in w\ \textstyle\sum_{(s,t)\in w} h(s,t)=c\} \qquad (4)$$

With c an odd integer greater than or equal to the window size. In obtaining the output Y(i, j) the WM filter generates h(s ,t) copies of X( i-s, j-t) for each (s, t) Є W, a total of c sample values. Thus Y (i, j) is represent as,

$$\mathbf{Y\ (i,\ j)\ =median}\{h(s,t)\in copies\ of\ X(i-s,j-t)\,|\,(s,t)\in w\} \qquad (5)$$

$$\mathbf{Y\ (i,\ j)} = \{Xij(a;2L+1)\}$$

$$\mathbf{Y\ (i,\ j)} = \{2L+2-a;2L+1\} \qquad (6)$$

**Y (i , j) =X(i , j)**

The WM filter with central weight h(0,0)=2K+1 and h(s, t)=1,for each (s, t)≠(0,0) is called the CWM filter. Where K is non negative integer value. The output Y ( i, j) of the CWM filter is given by,

**Y (i, j) =median{X (i-s , j-t),2K copies of X (i , j)|(s, t) ЄW}** (7)

Where K=0,the CWM filter becomes the median filter, when 2K+1 is greater than or equal to the window size 2L+1,it becomes the identity filter(no filtering).A CWM filter with a larger central weight performs better in detail preservation but worse in noise suppression than one with a smaller central weight.

## IV. THE WEIGHTED MEDIAN FILTER

A two dimensional (2D) weighted median filter (WMF) of extent 2n+1 to be the array of coefficients: {a(i,j):- n≤i , j ≤n: a(I ,j) non negative integers: sum(a(i, j); i, j=-n...n odd integer}.The operation of the filter at point (s,t) of a data array D is to take a(i, j) copies of D(s+I , t+j) for i, j=-n..n, a total of S=sum (a(i, j)=-n...n) values where S is odd. These are sorted into ascending order (L (K); k=1.....S) and the median M is taken, that is M=L(S+1)/2).

If |(M-D(s,t))|>T, where T is a given threshold value, possibly zero, then C(s, t)=M; otherwise C(s ,t)=D(s ,t),where C is the modified image.(Note that C is used rather replacing directly in D so as to avoid asymmetries and propagation effects in the filtered image that would then depend on the direction the filter is moved across the data.)

Logically C is then copied into D and in back grounding, the process may be repeated as long as some values of D are replaced. In practice, if the filter is reapplied is the input image and D the result image, or for greater space efficiency C may be replaced with rolling buffer of width equal to the filter extent and length equal to the image length. It should be noted that it is possible to have distributions where some filters leads to loop occurring where pairs of values are interchanged at each step.

One dimensional filters may be obtained by setting the appropriate elements of a to 0.For example, a horizontal filter is obtained by setting a(i, j)=0 for i≠0.Further,three-or higher dimensional filtering can be applied by a simple extension of the number of indices. The symmetric filters may be devised if required such as,

| | | |
|---|---|---|
| **0** | **0** | **0** |
| **0** | **2** | **1** |
| **0** | **1** | **1** |

Note that S is odd to provide a central value. If S even is allowed, an off-center value has to be chosen and this affects the symmetry of likelihood of selection of high or low values. Following the framework of switching median filter SAM filter is constructed from two stages, which are noise detection and noise cancellation. SAM are briefly given by two stages. MSE value is used to evaluate the correction error of the method. The measure is defined by:

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

$$MSE = 1/M\,N\,[\,\sum_{x=0}^{m-1}[g(x,y) - e(x,y)]^2 * \sum_{y=0}^{n-1}[g(x,y) - e(x,y)]\text{^}2 \quad (8)$$

Peak signal to noise ratio (PSNR) and correlation of the output image are computed to analyse the performance of the proposed filter as a denoising technique. The parameters used to define the performance of proposed filter are defined as follows:-

$$PSNR = 20\log10\,(255/RMSE) \quad (9)$$

Where RMSE,

$$RMSE = \sqrt{1/MN \sum_{i,j}(Yij - Xij)\text{^}2} \quad (10)$$

CORRELATION) is described by:-

$$CORR = \{\sum_{i,j}(Yij - \mu y) * (Xij - \mu x)\}/\{\sqrt{\sum_{i,j}(Yi,j - \mu y)^2 * (Xi,j - \mu y)\text{^}2}\} \quad (11)$$

Where Yij and Xij denote the pixel values of the restored and original image .M X N are the size of image, $\mu_x$ and $\mu_y$ are the pixel value of the mean of original and restored image. Flowchart for adaptive median filter is shown below

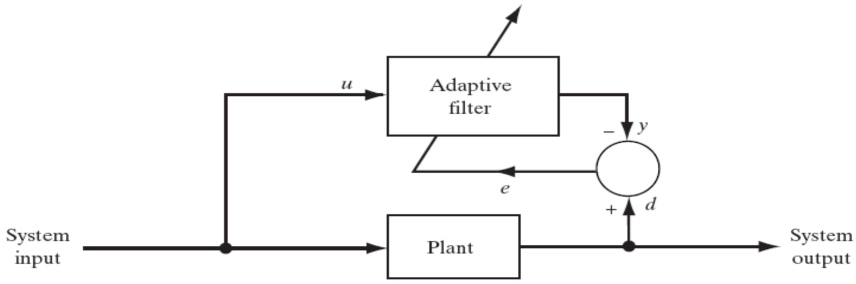


**Fig1: Adaptive Median Filter**

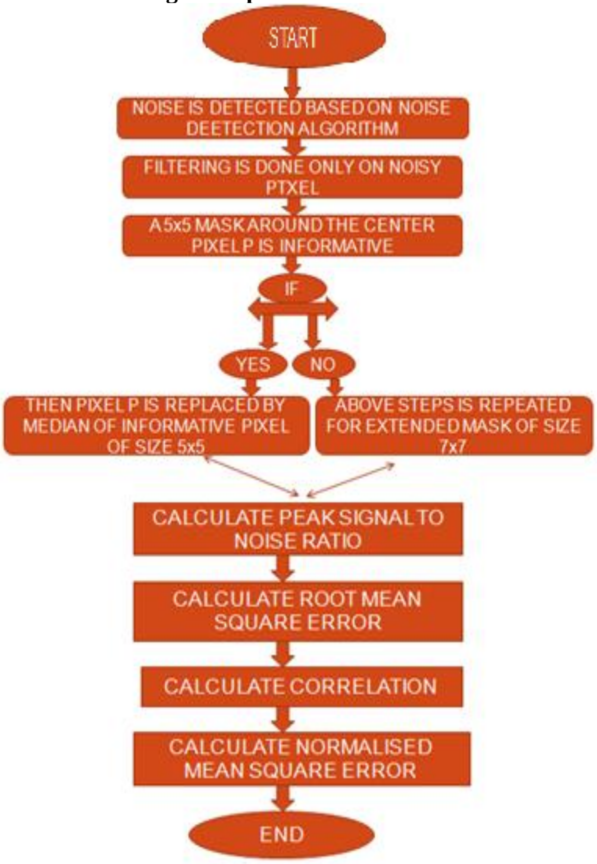


**Fig 2: Flowchart for ACWMF Algorithm**

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
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## V. COMPARATIVE ANALYSIS

TABLE 1 COMPARISON IN TEMS OF PEAK SIGNAL TO NOISE RATIO

| SR. NO | NOISE LEVEL | PSNR MF | PSNR CWMF | PSNR CWLMF | PSNR ACWMF | PSNR ACWAMF |
|---|---|---|---|---|---|---|
| 1 | 10 | 11.519 | 29.097 | 18.739 | 35.335 | 32.96 |
| 2 | 20 | 11.455 | 23.458 | 14.044 | 32.736 | 29.955 |
| 3 | 30 | 11.135 | 18.926 | 11.662 | 31.138 | 28.212 |
| 4 | 40 | 10.237 | 15.460 | 9.9982 | 29.805 | 26.927 |
| 5 | 50 | 9.7067 | 12.839 | 8.765 | 28.244 | 25.455 |
| 6 | 60 | 9.0849 | 10.741 | 7.7953 | 26.350 | 23.458 |
| 7 | 70 | 7.7813 | 9.1449 | 7.044 | 22.53 | 20.252 |
| 8 | 80 | 7.7259 | 7.7143 | 6.3714 | 16.012 | 15.957 |
| 9 | 90 | 7.7259 | 6.6098 | 5.8350 | 10.375 | 12.234 |
| 10 | 91 | 6.5441 | 6.5004 | 5.7891 | 9.7653 | 11.791 |

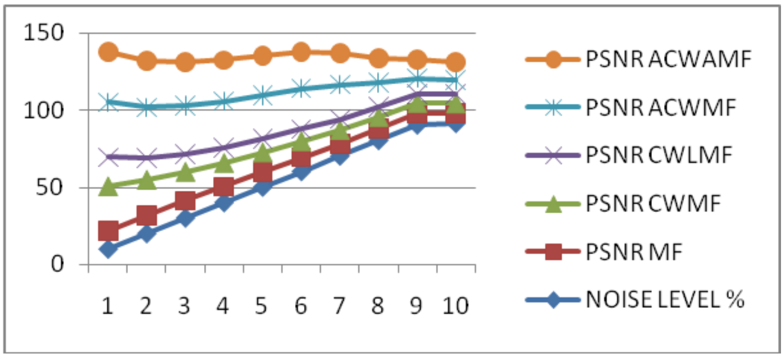



**Fig 3: Graph for PSNR for Different Filter**

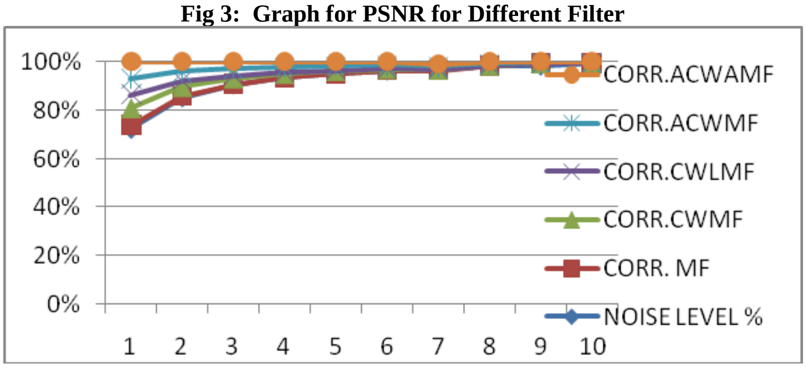


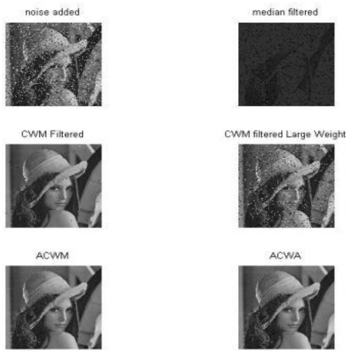

**Fig 4: Graph for Correlation for Different Filter**

TABLE 2 COMPARISONS IN TEMS OF CORRELATION

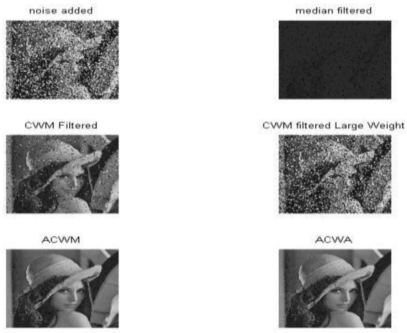
| SR.NO | NOISE LEVEL | CORR. MF | CORR. CWMF | CORR. CWLMF | CORR. ACWMF | CORR. ACWAMF |
|---|---|---|---|---|---|---|
| 1 | 10 | 0.1835 | 0.9661 | 0.7796 | 0.9415 | 0.9371 |
| 2 | 20 | 0.0897 | 0.9147 | 0.5811 | 0.9378 | 0.9293 |
| 3 | 30 | -0.0109 | 0.8061 | 0.4385 | 0.9340 | 0.9200 |
| 4 | 40 | -0.0025 | 0.6544 | 0.3295 | 0.9292 | 0.9115 |
| 5 | 50 | 0.00731 | 0.4983 | 0.2445 | 0.9217 | 0.8970 |
| 6 | 60 | 0.0077 | 0.3565 | 0.1785 | 0.9084 | 0.8697 |
| 7 | 70 | -0.3279 | 0.2528 | 0.1290 | 0.8603 | 0.7939 |
| 8 | 80 | -INF | 0.1444 | 0.0751 | 0.6448 | 0.5907 |
| 9 | 90 | 0.0904 | 0.0663 | 0.0368 | 0.3017 | 0.2979 |
| 10 | 91 | -INF | 0.0601 | 0.0347 | 0.2588 | 0.2620 |

## VI. RESULT

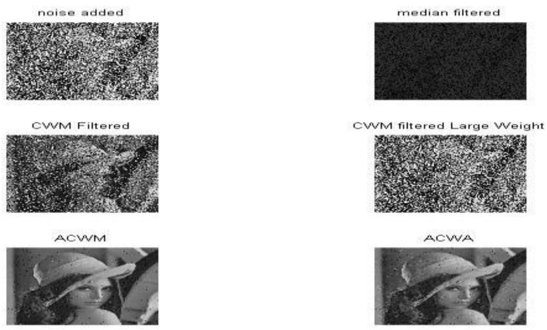
**Result for Noise Level 10%**




**Result for Noise Level 30%**




**Result for Noise Level 30%**




## VII. CONCLUSION

The contribution of circular filter and weighting process towards the performance of Simple Adaptive Median filter have been investigated, in terms of MSE value, Processing time and by visual inspection. Usually all methods produce almost equivalent result. Circular process and weighting process slightly reduce the MSE value. However circular filter requires a longer processing time and thus should be avoided in the design of real time processing system. In next phase the result is compared in between median filter, center weighted median filter, Adaptive centre weighted median filter, adaptive center weighted with large weight. From comparison conclusion is adaptive center weighted median filter can suppress more additive noise and impulsive noise. The CWM and ACWM filters, which are useful detail preserving smoothers where proposed and their properties where analyzed. The computation time required increases as noise density increases which are quite acceptable for the result is produces. The increase in computation time might be explained by fact that at higher noise densities the filter is applied again and again till the noise detector is unable to detect any noise in images. The threshold taken for gray level image is zero for which filter performs its best.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 1, January 2013

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