Evaluating the shortcomings of Median based filtering techniques

Lovepreet Kaur[1] Spardha Sethi [2]
[1,2]Computer Science and Engineering Department
[1,2]Chandigarh University, Gharuan(Punjab).

Abstract— This paper presents different image filtering methods to productively expel the noise from digital images. Noise in digital images may cause numerous issues for vision applications. So removing the noise in productive way has discovered to be significant region of exploration. This paper has reviewed different systems to expel diverse sort of noises from digital images. Different average based image filtering strategies are additionally considered in this paper. It has been discovered that the a large portion of the current strategies are productive for low density of noise yet not for high intensity. This paper has wind up with the different short comings of the different filtering strategies.

***Key words*:** Median filter, Salt-pepper noise, relaxed median filter

I. INTRODUCTION

In image processing, noise reduction and restoration of image is relied upon to enhance the qualitative examination of an image and the performance criteria of quantitative image analysis methods. Digital image is slanted to a mixture of noise which influences the quality of image. The principle reason for de-noising the image is to restore the detail of original image as much as possible. The criteria of the noise removal issue depend on the type of noise by which the image is corrupted. In the field of decreasing the image noise , few types of linear and non linear filtering procedures have been proposed. Distinctive methodologies for the decrease of noise and image enhancement [1] have been considered, each of which has its own limitations and advantages.

Image de-noising is an indispensable image processing task i. e. as a methodology itself and additionally a segment in different techniques. There are numerous approaches to de-noise an image or a set of data and methods exists. The essential property of a good image de-noising model is that it should completely remove noise as far as possible and in addition to preserve edges. Traditionally, there are two type of models i. e. linear model and non-liner model. For the most part, linear models are utilized. The main benifits of linear noise reduction models is the pace and the restrictions of the linear models is, these are not efficient to save edges of the images in a proficient way i. e. the edges, which are recognized as discontinuities in an image, are spread out. Then again, Non-linear models [2] can deal with edges in a greatly improved manner than linear models.

A. Applications of filtering

There are different application of filtering that can help in image improvement and reclamation. Some of them are described followed

1) Noise Smoothing

Linear filters are useful for smoothing most types of noise; however this is at the cost of edge sharpness and fine detail. These limits might be overcome by utilizing trimmed filters. The MEDIAN filter is useful for smoothing noise while protecting edges.

2) Edge Enhancements

Edge enhancement is frequently accomplished by steepening the edge incline. At the point when linear filters are utilized for this, it comes about on edges which are sharp. Nonlinear filter works more reasonably well in preserving edges with the assistance of different order statistics filters.

3) Edge Detection

Linear edge detection filters [3] might be made to detect edges in one specific direction or in all directions without a moment's delay. Numerous nonlinear filters have been designed to enhance edge direction in the presence of noise.

II. TYPES OF NOISES

The fundamental source of noise in digital images emerges during image acquisition (digitization) or during image transmission. The execution of image sensor is influenced by mixture of reasons, for example, ecological condition during image procurement or by the quality of the sensing component themselves. For example, during obtaining images with CCD camera, sensor temperature and light levels are main considerations that influencing the measure of noise in the image after the resulting. Images are ruined while during transmission of images. The important reason of noise is because of interfering in the channel which is utilized for the images transmission. We can model a noisy image as takes after:

$$C(x, y) = a(x, y) + b(x, y)$$

Where A(x, y) is the first image pixel value and B(x, y) is the noise in the image and C(x, y) is the resulting noise image [4]. There are different types of noise models as indicated in Figure 1.

A. Uniform Noise

The uniform noise cause by quantizing the pixels of image to various different levels is known as quantization noise.This has approximately uniform distribution. In the uniform noise the level of the gray values of the noise are consistently distributed over a defined reach.

B. Gaussian Noise or Amplifier Noise

This noise has a Probability Density Function of the ordinary dispersion. It is otherwise called Gaussian distribution. It is a significant piece of the read noise of an image sensor that is of the consistent level of noise in the dark areas of the image.

C. Salt and Pepper Noise

The salt-and-pepper noise[4] are additionally called shot noise, drive noise or spike noise that is normally created by faulty memory areas, malfunctioning pixel components in the camera sensors, or there might be timing errors at present digitization . For 8-bit image the normal worth for 255 for salt-noise and pepper noise is 0.

D. Rayleigh Noise
Radar reach and speed images commonly hold noise that might be modeled by the Rayleigh dispersion**.**

E. gamma Noise
The noise could be obtained by the low-pass filtering of laser based images.

III. FILTERS
Filtering [5] in an image handling is a premise work that is utilized to accomplish numerous assignments, for example, noise reduction, interpolation, and re-sampling. Filtering image data is a standard methodology utilized as a part of just about all image processing frameworks. The decision of filter is determined by the way of the assignment performed by filter and conduct and type of the data. Filters are utilized to reduce noise from digital image while keeping the details of image preserved is a fundamental part of image processing. Filters could be described by different classifications

(1) Spatial Domain Filtering
(2) frequency Domain Filtering

A. Spatial Domain Filtering
The Spatial Domain [2]is a domain (the plane) where a digital image is defined by spatial coordinates of its pixels. The spatial domain procedures could be represented by the accompanying expression g(x, y) =t [f(x, y)]where f(x, y) is the input image, g(x, y) is the output image and T is an administrator defined over a nearby neighborhood of pixel with the coordinates(x, y). There are two types of spatial filters.

1) Low Pass Spatial Filtering [1]
The most straightforward manifestation of spatial filtering is an uniform neighborhood averaging. This is refined utilizing a spatial mask of all ones. The impact of low pass filtering is to make edges more diffuse and low contrast.

2) Median Filtering
Average filtering [6] is carried out one neighborhood at once; however the veil that it uses is not a linear capacity. An average filter[7]replaces the pixel with the median of the neighborhood. This is helpful in reducing noise from an image. The average filter [11] does this by removing large noise spikes from the image.

3) High Pass Spatial Filtering
The impact that high pass filters have on an image is precisely inverse that of low pass filters. The essential objective of low pass filtering is to highlight detail or to improve lost detail because of blurring in image acquisition. This is attained utilizing a mask having a positive value in its focal point area and negative coefficients in the rest. A high pass [13] filtered image may be figured likewise as the distinction between the original image and a low pass filtered version of the image.

4) High Boost Filtering
In this a blurred image is subtracted from original to get unsharp mask image, then we include a numerous of unsharp mask to unique to get sharpened image. Sample of high boost filtering is Unsharp Masking.

B. Frequency Domain Filtering
These techniques are focused on modifying the spectral transform of an image. It transforms the image to its frequency representation and performs image processing and after that it processes inverse transform back to the spatial domain. High frequencies relate to pixel values that change quickly over the image (e. g. content, texture, leaves, and so forth.). Strong low frequency segments relate to huge scale offers in the image (e. g. a single, homogenous object that commands the image).

1) Smoothing Frequency Domain Filters
Smoothing is accomplished in the frequency domain by dropping out the high recurrence segments.
The fundamental model for filtering is:

$$G(u, v) = H(u, v)\, F(u, v)$$

Wheref (u, v) is the Fourier transform of the image being filtered and H (u, v) is the filter transform function.

Low pass filters – just pass the low frequencies, drop the high ones.

2) Sharpening Frequency Domain Filters
Edges and fine detail in images are connected with high frequency components.

High pass filters – just pass the high frequencies, drop the low ones. High pass frequencies are exactly the reverse of low pass filters, so:

$$H_{hp}(u, v) = 1 - H_{lp}$$

IV. MEDIAN FILTER
Salt and pepper noise is typical type of image noises, coming about because of image sensors, channel transmissions and decoding processing etc. It altogether lessens the image quality and its filtering execution has an immediate effect on the image processing. A considerable measure of filtering systems are proposed to take out salt and pepper noise.

A most successful method amongst the best techniques is average filter [17].The median filter is a nonlinear sign processing method focused around facts. The noise estimation of the digital image or the arrangement is replaced by the average estimation of the area (mask). The pixels of the mask are positioned in the order of their gray levels, and the median estimation of the gathering is put away to replace the boisterous worth. The median filtering [18] output is

$$g(x, y) = \text{med}\,\{f(x - i, y - j),\ i, j \varepsilon w\}$$

where f (x, y),g(x, y) are the first image and the output image respectively, W is the two-dimensional mask: the mask size is n * n(where n is usually odd, for example, 3* 3, 5 * 5, and so forth.; the mask shape may be linear, square, round, cross, and so on.

In median filtering, the neighboring pixels are ranked according to brightness i.e. force and the median value becomes the new value for the focal pixel. Median filters can make a fantastic showing of rejecting certain types of noise, specifically, shot or impulse noise in which some individual pixels have extreme values.in the median filtering operation, the pixel values in the area window are positioned according to intensity, and the center esteem (the average) becomes the output value for the pixel under evaluation.

A. Advantages of Median Filter
(1) There is no decrease in contrast over steps, since output values available comprise just of those resent in the neighborhoodarea.
(2) Median filtering does not move boundaries, as can happen with traditional smoothing filters.

(3) Since the median is less sensitive than the mean to extreme values i.e. outliers, those extreme values are all the more successfully removed.
(4) The median is more robust than the mean, as it is not influenced by the extreme values.
(5) Since the output pixel value is one of the neighbouring values, new unreasonable values are not created near edges.
(6) Since edges are insignificantly degraded, median filter scan be applied more than once, if needed

V. Hybrid Median Filter

Hybrid median filter is windowed filter of nonlinear class that effortlessly removes impulse noise while preserving edges. In comparison with essential version of the median filter hybrid one has better corner preserving aspects. The essential idea behind filtering is to choose any components of the image and apply median statistics a few times by varying window shape and after that take the median of the got median values i.e. median of medians

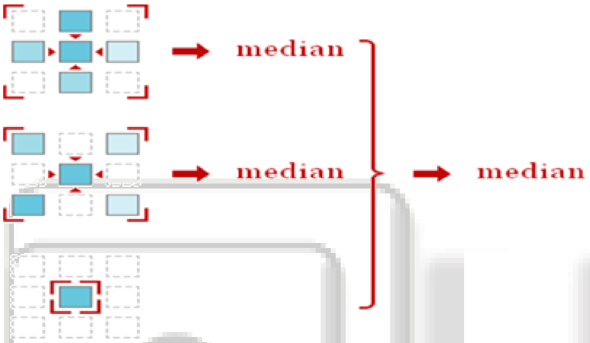

Figure 1 Hybrid Median Filters

A. *Advantages of Hybrid Median Filter*

Hybrid Median filter [8] is of nonlinear class that easily reduces the impulse noise while preserving edges. The hybrid median filter plays a vita role in image processing and image vision. In comparison with basic version of the median filter, hybrid one has better corner preserving attributes. This filter is defined as

A hybrid median filter preserve edges much superior to a median filter. In hybrid median filter the pixel value of a point p is replaced by the median of median pixel value of 4-area of a point 'p', median pixel value of cross neighbors' of a point "p" and pixel value of "p".

VI. Relaxed Median Filter

The median filter is far from being a perfect filtering technique as it reduces fine details, sharp corners and thin lines. The principle reason is that the ordering procedure destroys any structural and spatial neighbourhood data. As an option to median filter, a version of median filter, the relaxed median filter is utilized. This filter is acquired by relaxing the order statistic for pixel substitution. By utilizing a relaxed median filter, more image details might be protected than the standard median filter. This strategy won't present any blocky impacts in images furthermore preserves fine details, sharp corners and thin lines and bended structures superior to median filter**.**

A. *Properties of Relaxed Median Filter*

The relaxed median filter is acquired by relaxing the order statistics for pixel substitution. Noise weakening properties and also edge and line preservation are analyzed factually. The performance of the relaxed median filter ought to be described by utilizing a few facts of the output. . However it is still conceivable to acquire the probability distribution function of the output by making basic suspicions about the first image (before being defiled by noise). In this sense, the noise attenuation could be decently evaluated from homogeneous originals and the detail preservation might be gotten to from pure edges and lines.

VII. Adaptive Median Filter

AMF is an new and updated version of median filter. It effectively reduces fixed valued impulse noise types (salt & pepper noise) from image. AMF increases size of the window during filtering depending on specific conditions. This is the most difference of adaptive median filter from other median type filters. AMF utilization has 3 fundamental purposes**:**

(1) to remove the salt & pepper noise;
(2) to smooth different noises**;**
(1) To reduce the distortions such as excessive thickening or thinning of object boundaries

Notation:

$Z_{\min}$ is minimum gray level value in window S_{xy};

$Z_{\max}$ is maximum gray level value in S_{xy};

Z_{med} is median of gray levels in S_{xy};

Z_{xy} is gray level value at (x, y);

$S_{\max}$ is maximum allowed size of S_{xy}.

AMF algorithm is divided into two levels:

Level A:

$A1 = Z_{med} - Z_{\min}$;

$A2 = Z_{med} - Z_{\max}$;

if $A1 > 0$ and $A2 < 0$
Go to Level B;
else
Increase the window size by 2;
end
if $window\_size \le S_{\max}$
Repeat Level A;
else
Output Z_{xy};
end

Level B:

$B1 = Z_{xy} - Z_{\min}$;

$B2 = Z_{xy} - Z_{\max}$;

if $B1 > 0$ and $B2 < 0$
Output Z_{xy};
else
Output Z_{med};
End

VIII. ADVANCED ADAPTIVE MEDIAN FILTER

The noise corrupted pixels in the image are found. To do this, the noisy gray-level values must be known. For SPN noise, the gray-level values are 0 and 255. However, for RVIN noise, the gray-level values are random values between 0 and 255.

A. *Find the noise gray-level values.*

$N_{\min}$ is a small gray-level value of noise;

$N_{\max}$ is a big gray-level value of noise.

B. *Change the gray-level values of the noise pixels.*

if $X_{ij} = N_{\min}$

$X_{ij} = 0$

if $X_{ij} = N_{\max}$

$X_{ij} = 255$

Figure 2 has shown the noisy image corrupted with density =.9. It is clear that the noise has degraded most of the visibility of the image.

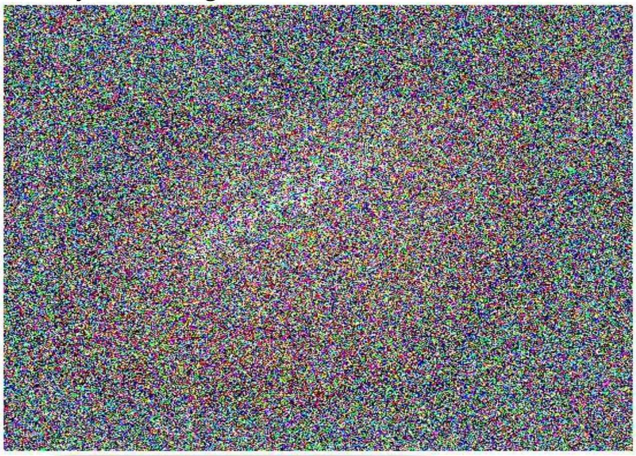

Figure 2 Noisy image with 90% noise

Figure 3 has shown the filtered image utilizing the traditional median filtered image. It is plainly demonstrated that the image is somehow filtered however has not represented the accurate results.

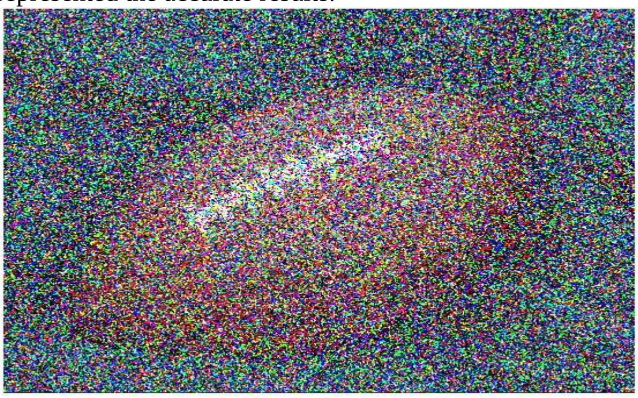

Figure 3 Median filtered image

Figure 4 has shown that the noise has been reduced by using the relaxed median filter but results are not that much effective.

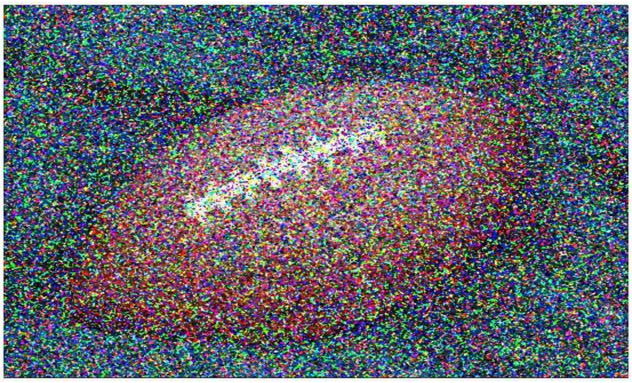

Figure 4 Relaxed median filtered image

Figure 5 has demonstrated that the results are very effective and has substantially more preferable outcomes about over the available methods. Accordingly the adaptive median filter has indicated truly huge improvement over the accessible techniques.

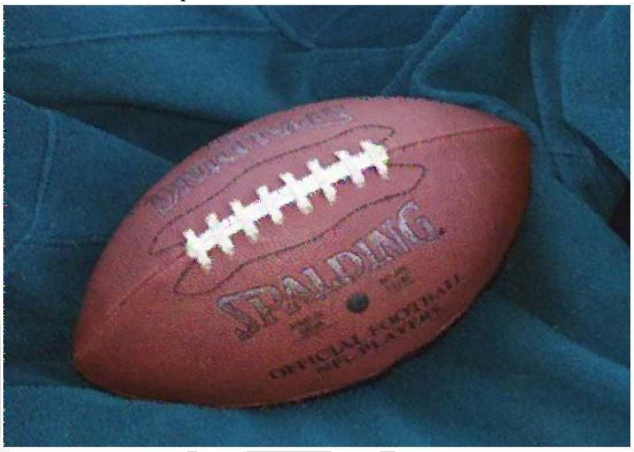

Figure 5 Adaptive median algorithm's filtered image

IX. SOME OTHER FILTERING TECHNIQUES

A. *Gaussian Filtering*

Gaussian filter [11] [15] change the input signal by complexity with a gaussian function. This type of filtering is utilized to reduce noise from the image.

The gaussian function is utilized as a part of a few zones:

- it clarifies a probability distribution for noise or information.
- it is a smoothing specialist.
- it is likewise utilized within arithmetic.

gaussian function is spoken to by this mathematical equation:

$$Gx) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-x^2}{2\sigma^2}}$$

When functioning with images we require to apply the two dimensional Gaussian function. and is given by this formula.:

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{\frac{-x^2+y^2}{2\sigma^2}}$$

This is basically the result of two 1d Gaussian function (one for every direction) . In this formula x shows the separation from the starting point in the horizontal axis, y shows the separation from the origin in the vertical axis, and σ is the standard deviation of the gaussian distribution. Values obtained from this dispersion are utilized to build a convolution matrix which is applied to the original image.

Each pixel's new value is set to a weighted average of that pixel's neighbourhood. The Gaussian filter is a non-uniform low pass filter. At the point when this formula is applied in two dimensions, it creates a plane whose forms are concentric circles with a Gaussian distribution from the inside point. The kernel coefficients debilitate with developing separation from the kernels centre. Focal pixels have a higher weighting than those on the edge. Bigger values of σ make a wider peak (much blurring). Kernel size must develop with expanding σ to protect the Gaussian nature of the filter. The kernel is rotationally symmetric with no directional bias. Gaussian kernel is distinguishable which permits quick computation.

1) Advantages

(1) Gaussian smoothing is extremely compelling for removing gaussian noise
(2) the weights give higher implications to pixels close to the edge (lessens edge blurring)
(3) they are linear low pass filters
(4) computationally efficient (vast filters are actualized utilizing little 1d filters)

2) Disadvantage

(1) Takes time and reduces details

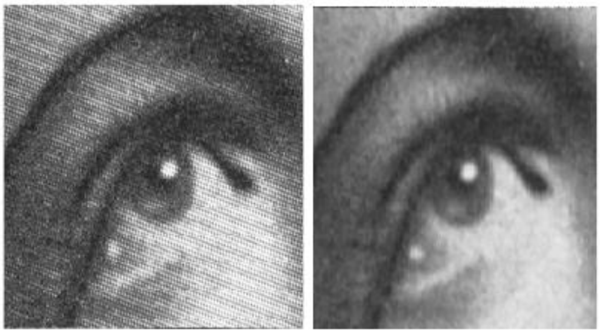

Fig 1 (a) Noisy Image (b) result of gaussian filtering.[12]

Fig 1(a) demonstrates a noisy image which is to be de-noised in order to get a noise free image. Fig 1(b) demonstrates the de-noised version of previous image. Image is de-noised by utilizing the idea of gaussian filtering

B. Bilateral filtering

A bilateral filter is an image de-noising strategy to remove the noise from the image .it goes under the class of non-linear filter. Here ,value at every pixel in an image is replaced by a weighted average of values from close by pixels. This weight could be focused around a gaussian distribution. essentially, the weights depend on euclidean separation of pixels, as well as on the radiometric difference.This is otherwise called edge-preserving and noise-reduction smoothing filter for images This converse pointed edges by altogether circling through every pixel and conforming weights to the neighbouring pixels as needs be. The bilateral filter is defined as

$$I^{\text{Filtered}} = \frac{1}{\mathrm{W_P}} \sum_{x_i \in \Omega}^{n} I(\mathrm{X_I})\, \mathrm{F_R}\left(\left|\left|I(x_i) - I(x)\right|\right|\right) g_s\left(\left|\left|x_i - x\right|\right|\right)$$

Where the normalization term ensures that the filter preserves image energy

$$\mathrm{W_P} = \sum_{x_i \in \Omega}^{n} \mathrm{F_R}\left(\left|\left|I(x_i) - I(x)\right|\right|\right) g_s\left(\left|\left|x_i - x\right|\right|\right)$$

– I^{Filtered} Is the filtered image and i is the original input image that is to be filtered;
– x are the coordinates of the current pixel to be filtered;
– f_r Is the range kernel for smoothing differences in intensities.This function can be a gaussian function

1) Advantages

(1) Averaging is goodto remove random noise from the images
(2) To improve the de-noising efficiency

2) Disadvantage

(1) Bilateral filtering is slow

Fig 2 (a) original image (b) result of bilateral filtering.[13]

Fig 2(a) shows the original image fig 2(b) shows the de-noised version of noisy image by using the concept of bilateral filtering

C. Non-local Means

Non-local means[19] is a algorithm that is utilized as a part of image handling for image de-noising. Different filters, for example, local filters that update a pixel's value with a average of the pixels around it. Anyway non-nearby filters [12] redesigns the pixel value by utilizing a weighted average of the pixels that are judged to be most similar to it. The local smoothing systems was not skilled for protection of the fine structure, details and surface. So the details and fine structures are smoothed out in light of the fact that they act in all generally designed angles as noise. The nl-means algorithm tries to take the advantage o the high degree of repetition of any ordinary image. A non-neighbourhood [14] system called as non-nearby means evaluates a without noise pixel force as a weighted normal of all pixel intensities in the image, and the weights are with respect to the likeness between the nearby neighbourhood of the pixel being transformed and nearby neighbourhoods of neighbouring pixels. Given a boisterous [16] image, the de-noised image at pixel is registered utilizing the given formula .This whole is ideally performed over the entire image.

$$NL[U](i) = \sum_{j \epsilon I} w(i,j) v(j)$$

Where the weight w(i,j) [6] depends on the distance between observed gray level vectors at points i and j.such distance can be represented as

$$d = \| \ |v(N_i) - v(N_j)||_{2,a}^2$$

So the weight [4][8]can be defined as

$$w(i,j) = \frac{1}{Z(i)} e^{\frac{-\left|\left|v(N_i) - v(N_j)\right|\right|_{2,a}^2}{h^2}}$$

Fig 4(a) noisy image (b) result of non-local means [15]

Fig 4(a) demonstrates the noisy image that is affected by the Gaussian noise.fig 4(b) shows the de-noised version of previous noisy image. Image is de-noised by using the concept of non-local means.

1) *Advantage*
   (1) This method work efficiently for the removal of noise and it give better result as compared to the previous available denoising techniques that leads to the smoothning of image.
2) *Disadvantage*
   (1) This denoising method work only for low level of intensity.

D. *Non-local Medians*

Non-local Euclidean [17] is an image de-noising strategy. De-noising performance of a noisy image enhanced by replacing the mean by the euclidean median and this new de-noising algorithm the non-local euclidean medians (NLEM). This strategy demonstrates that the median is a larger number of vivacious to outliers than the mean [19] [20]. Nlem performs unrivaled than nlm in the adjacent range of edges, mainly on the large noise levels. Nlem might be efficiently implemented using iteratively reweighted least[3] squares.theeuclidean mean is the minimizer of $|\ \ |v(N_i) - v(N_j)||^2$ Over all patches and euclidean median is the minimizer of $|\ \ |v(N_i) - v(N_j)||$ Over all patches .by using the concept of euclidean median must better result is obtained as compare to non-local means but at high noise level.

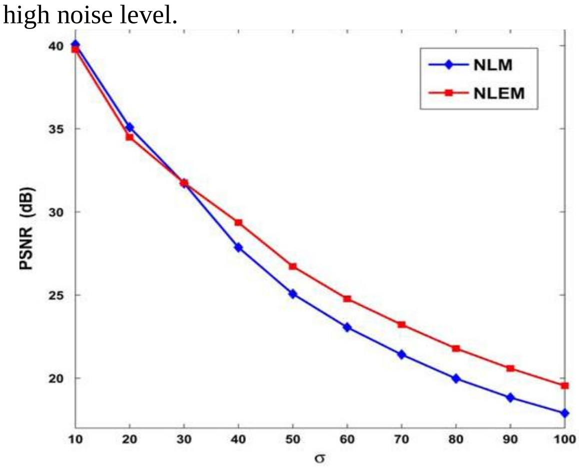

Fig 5 NLM AND NLEM [17]

This figure demonstrates the graphical consequence of non-local means and non-local median. median show better come about then mean.

1) *Advantage*
   (1) this strategy [18] is utilized to enhance the de-noising performance of nlm in the region of edges utilizing the euclidean median.
2) *Disadvantage*
   (1) this strategy work just for high density noise.

X. RELATED WORK

A [1] new algorithm Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) which gives better performance in correlation with existing noise removal algorithm as far as PSNR and IEF. Indeed at high noise density levels the MDBUTMF gives better brings about examination with other existing algorithms.

A novel Sorted Switching Median Filter (SSMF) [2] can adequately denoising amazingly ruined images while protecting the image details. The focal point pixel is considered as ""uncorrupted"" or ""defiled"" noise in the detecting stage. The debased pixels that have more without noise surroundings will have higher transforming necessity in the SSMF sorting and filtering stages to protect the intensive noisy neighbours.

Enhancement of a noisy image [3] is essential undertaking in digital image preparing. Filters are utilized best for removing noise from the images. Filters methods [3] are divided into two sections linear and non-linear systems. After studying linear and non-linear filter each of have restrictions and advantages. In the hybrid filtering plans, there are two or more filters are recommended to filter a corrupted location. The decision to apply a specific filter is focused around the diverse noise level at the distinctive test pixel area or performance of the filter scheme on a filtering mask.

Adaptive Two-Stage Median Filter (ATSM) [4] is utilized to de-noise the images tainted by altered value impulse noise. ATSM is ended up being better as far as Peak Signal-to-Noise Ratio and human visual observation. This filter is effective in de-noising the highly corrupted image.

New technique [5] has utilized the idea of substitution of noisy pixels by linear expectation preceding estimation. A novel simplified linear indicator is developed for this reason. The goal of the plan and calculation is the reduction of high-density salt and pepper noise in images.

A novel switching median filter [6] joining with an effective impulse noise detection strategy could be utilized for successfully de-noising greatly tainted images. To determine whether the current pixel is corrupted, the algorithm first classifies the pixels of a confined window, centering on the current pixel, into three group lower power impulse noise, uncorrupted pixels, and higher force impulse noise.

The adaptive median filter algorithm [7] is attained by detecting the contamination level of the image, discovering the particular area of the noise and determining the extent of the median filtering window adaptively. The algorithm has improved the accuracy of noise detection and the fidelity of image filtering, and has a superior performance on distinctive noise densities.

An enhanced median filtering calculation [8] has utilized the connection of the image to process the peculiarities of the filtering mask over the image. It can adaptively resize the mask as per noise levels of the mask.

The measurable histogram is additionally presented in the looking procedure of the median value.

A statistical filter [9] is an adjusted version of Hybrid Median Filter for spot lessening, which processes the median of the inclining components and greatest of the horizontal and vertical components in a moving window lastly the two values are compared with the focal pixel and the median value of the three values will be the new pixel value. The filter is tried on phantom Ultrasound image.

Relaxed median filter[10] is acquired by relaxing the order detail for pixel substitution. Noise weakening properties and edge and line safeguarding are investigated measurably. The trade-off between noise disposal and detail safeguarding is widely examined. It is demonstrated that loose median filters protect details superior to the standard median filter, and remove noise superior to other median type filters.

XI. GAPS IN STUDY

The study has demonstrated that the vast majority of existing researchers has ignored no less than one of the following.

(1) the impact of the global mean if there should arise an occurrence of all the noisy pixels in a given mask has been overlooked.
(2) the uproarious pixels 0 or 255 are considered in the input set while calculating the median; so focus pixel may be off and on again replaced by the noisy pixel once more.
(3) most of the current examination has additionally ignored the impact of the high density of the noise.

XII. CONCLUSION & FUTURE WORK

The study has demonstrated that the still much enhancements are needed in the filtering methodology. The impact of the global mean if there should arise an occurrence of all the noisy pixels in a given mask has been ignored by the majority of existing researchers. As median base filtering smooths even the edges of the regions. So near future we will propose another modified median filter to improve the results further. Likewise to approve and check the proposed algorithm MATLAB simulator will also be used.

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