# A SURVEY ON VARIOUS TYPES OF FILTER FOR RESTORATION OF NOISY IMAGE

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**Abstract**:

*Image play a very important role in every aspect of life and it play a vital role in the area of research of digital image processing. So reduction of noise and restoration of image is very much essential. This paper describes type of noise that can affect an image and various type of filter for restoration of that noise. In this paper a review of various filter is taken which is already proven by other scientist .Every noise has its own character which is described briefly. Here various types of filter with there advantage and disadvantage and efficient for whish specific type of image is described thoroughly .At last a tabular representation of all the filter with its advantage disadvantages and future scope is represented.*

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## 1. INTRODUCTION:

The most important sensor of humane body is vision system .The Image processing deals with the image i.e. to produce the appropriate processed image for various applications in day-to-day life. It play vital role in many field such as astronomy, medical image and image for forensic laboratories. Image used for this aspect must be noise free. So noise detection and its reduction play an important role in all aspect of life.

Noise is an error or unwanted signal or information which destroys image quality. It is the random variation in image quality that produces different intensity value of pixel instead of true pixel value. In Mathematically Noise is defined as a process (n) which effect images (F) and is not part of the scene. Usually the additive noise model, the process can be defined as

$$F(i, j) = S(i, j) + n(i, j) \quad (1)$$

In Digital Image noise may come from various sources. The acquisition process for digital image converts optical signal into electrical signal and then into digital signal. [1]

## 2.TYPE OF NOISE

There are different types of noise in image which can destroy image quality. These noise are described below

1. Uniform noise
2. Gaussian noise
3. Salt and Pepper noise
4. speckle noise
5. Poisson noise
6. Rayleigh noise

### 2.1.Uniform noise:

When the grey level value of the noise is distributed uniformly in an image in a specific range then this type of noise is called a uniform noise [2].

The probability distribution of uniform noise is

$$Pu(z) = \begin{cases} 1/(b-a) & if\ a \le z \le b \\ 0 & otherwise \end{cases} \quad (2)$$

Mean= a+b/2

Variance= $(b-a)^2/12$

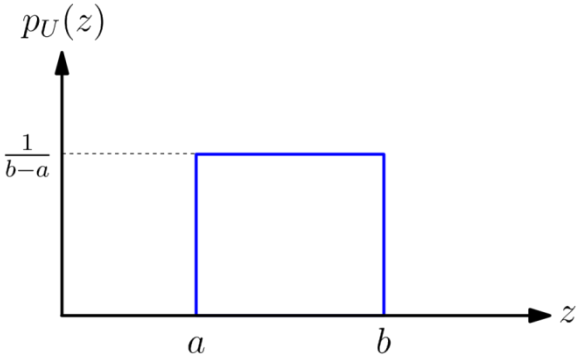


**Fig 1.**Uniform noise

**2.2.Gaussian noise/Amplifier noise:**

It is a statistical noise that has a probability density function (PDF) of the normal distribution also called as Gaussian distribution. In this noise each pixel in the noisy image is the sum of the true value and a random Gaussian distributed noise [3] value. The noise is independent of intensity of pixel value at each point.

The PDF of Gaussian random variable is given by

$$F(g) = 1/\sqrt{2\pi\sigma^2}e^{-(g-m)^2/2\sigma^2} \quad (3)$$

F (g) = Gaussian distribution noise in image

$\sigma$ = Standard deviation

m = mean value

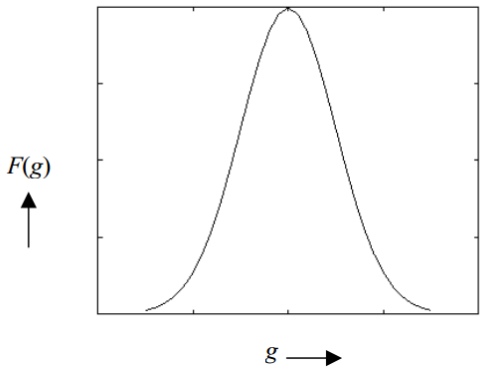


**Fig -2:**Bell Shaped Curve for Gaussian distribution

**2.3.Salt and pepper noise/Impulse noise:**

The Impulse noise is also called salt and pepper noise [4]. Black and White dotes appears in the image .As a result it is called as salt-and-pepper noise. Image having salt and pepper noise will have dark pixel in bright area that contain the extremely low value 0 and bright pixel in dark

areas that contain the extremely high value 1. The noise arises in the image because of sharp and sudden change in image signal [2].

For 8 bit image, the typical value for pepper noise is 0 and 255 for salt noise.

The PDF of impulse noise is given by

$$P(z)=\begin{cases} p_a & for\ z=a \\ p_b & for\ z=b \\ 0 & otherwise \end{cases} \quad (4)$$

If b>a, intensity 'b' will appear as light dot in the image. Otherwise intensity 'a' appears like a dark dot.

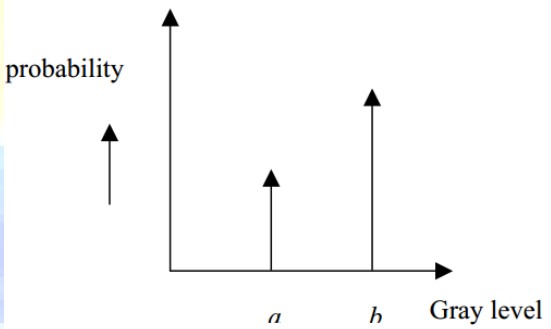


**Fig-3:** Salt and Pepper Noise

3.3.**Speckle noise:**This noise can be modelled by random value multiplications with pixel values of the image and can be expressed as

$$J = I + n*I \quad (5)$$

Where, J is the speckle noise distribution image, I is the input image and *n* is the uniform noise image by mean *o* and variance *v*. This noise deteriorates the quality of] images. This noise is originated because of coherent processing of back scattered signals from multiple distributed points [5].

ppppp

Fig-4:Speckle noise

**2.4.Poisson Noise/photon noise:**

Poisson noise [6] is appears when the number of photon sensed by the sensor is not sufficient to provide detectable statistical information[3]. This type of noise is formed due to the electromagnetic wave such as x-ray, visible light and gamma ray. The probability density function of photon noise is

$$P(P/\rho, T) = (\rho^T)^P e^{-\rho T} / P!$$

**W**here ρ is the rate of intensity parameter measured in photon per T second

**2.5.Rayleigh noise:**Radar range and velocity images typically contain noise that can be modelled by the Rayleigh distribution [7].

The probability density function of Rayleigh noise [] is

$$P(z) = \begin{cases} 2/b(z-a)e^{-\frac{(z-a)^2}{b}} & for\ z \geq a \\ 0 & for\ z < a \end{cases} \quad (7)$$

Mean =a+$\sqrt{\pi b/4}$

Variance $\sigma^2$=b (4-$\pi$)/4

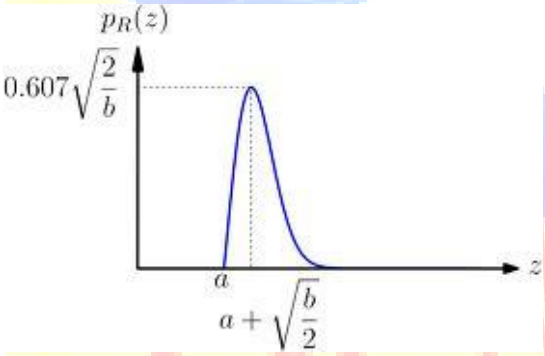


Fig-5:Rayleigh noise

2. **LITERATURE REVIEW:**

The task of noise reduction attract both for neuroscientists and for computer vision scientist. There are various approaches of noise reduction. These approaches determine which filtering technique is efficient to clear a noise from an image without destroying the detail data and edges of that given image.

The following section gives an overview on the image filtering technique that apply mostly on the impulsive noise i.e. salt & pepper noise.

**a. MEDIAN FILTER:**

Median filter [7] is the oldest method for filtering the impulsive noise. It applies the median operation to each pixel irrespective of the noise or noise free property of the pixel in the image. As a result the uncorrupted pixel is also filtered and this causes degradation in image. In this technique the pixel value is replaced with the median value. The median of a picture is calculated by first shorting all the pixel value into ascending order and replacing the centre value with the middle pixel value. If the neighbour pixel of the image which is to be consider contain an even number of pixel, then the average of the two middle pixel value is replaced with the middle value.

**Table-1 Evaluation of median value from a number of pixels**

| | | |
|---|---|---|
| 10 | 5 | 20 |
| 14 | 80 | 11 |
| 8 | 3 | 22 |

3, 5, 8, 10, 11, 14, 20, 22, 80

Median (centre value 80 is replaced by 11)

Advantage:

1. It is easy to implement.
2. It is used to di-noising different type of noise.

Disadvantage:

The median pixel gives best result when the impulse noise percentage is less than 0.1 %. When the quantity of impulse noise is increased the median filter not gives the best result.

**b. ADAPTIVE MEDIAN FILTER:**

To overcome the inefficiency of the Median filter the Adaptive Median filter [8] came in to existence. Here the filter identifies possible noisy pixels and then replaces them with median value or its variance leaving the other entire pixel or noise free pixel unchanged. The main disadvantage of this approach is that the local feature such as the possible presence of edges is not taken into account. Due to which the detail and edges are not recovered properly when the noise level is high. When the noise level is above 50% some details and edges of the original imaged are destroy.

Advantage: De-noise the noisy pixel leaving the noise free pixel unchanged. It helps in preserving the detail of the real image.

Disadvantage:

1. The possible edges of image are not taken into account.
2. When the noise level of the image is more than 50% some detail of the image is destroyed.

**a. DETAIL PRESERVING FILTERING:**

Detail preserving filtering [9] is another approach in detection of salt and pepper noise. This approach is proposed byS.Md.Roomi et al. This filter maintain higher peak to signal ratio (PSNR) to preserving the edge and noise ratio of a corrupted image.

In this filtering process first the noise and edge of the corrupted image is detected then the adoptive impulsive noise detection process is applied. Here the blur of image is detected by the following formula

Blur of an image=sum of all edge/no of edge

Here the noise detection is carried out by two process

First the noise pixel present in the edge i.e. $N_e(i , j)$ is detected. Secondly the noisy pixel not present on the edge $N`_e(i , j)$ is detected.

The edge is find-out by using the connectivity of the edge pixels.

$N_8(p)=N_4 \cup \{(i+1 , j+1),(i+1 , j-1),(i-1 , j+1),(i-1 , j-1)\}$

Where $N_8(p)$ is 8-connected neighbour and $N_4(p)$ is the 4-connected neighbour for the pixel N`(i , j)

For detection of the edge following formula is used

$S1_{i , j}=\{med(y)_{i , j=s, t} \forall Ne_{i , j}=1$

Here $S1_{i , j}$ is the filtered output

$Ne_{i, j}$=Noisy edge

[s , t]=Size of the window

(i , j)=Pixel of the noisy image

The size of the window[s , t] is greater in the direction of the edge having non noisy pixel.

Again the non-noisy neighbourhood of the image is calculated by the followinh formula

$S2_{i,j}=\{med(v)_{i,j=s,t} \forall Ne_{ij}=1$

$Ne_{ij}$= noisy pixel not on the edge of the image

S2(i , j)=filtered output

[s , t]=mask size

[i , j]=pixel of the noisy image

The final filtered is obtained by $S(i , j)=S1_{ij} \cup S2_{ij}$

Disadvantage: It is an iterative process, so the time consumed to reduce the noise is more.[6]

**d. Tolerance based selective Arithmetic mean filtering technique (TSAMFT)**

This filtering has proposed by Ms.P.H.Sangava et al. This technique [10] is based on decision based filter to remove low to high value of salt-and-pepper noise as well as edge preservation. It reduces the lacuna of the Arithmetic mean filter.

In the Arithmetic mean filtering technique all the pixel value from 0 to 255 of a noisy grey scale image is taken in consideration. But this calculation produces inaccurate result by blurring the final detail of the image.

So in this TSAMFT technique it ignore the extreme value of the image i.e 0 and 255.Again if the number of pixel value is greater than $1/3^{rd}$ of m×n(mask of the image) then the TSAMFT technique is applied otherwise the Arithmetic mean filtering technique is used.

Advantage:

The proposed filter is good for grey scale image with difference noise model for salt and pepper noise.

Disadvantage:

The above filter is not good for colour image.

e. OPTIMAL MORPHOLOGICAL FILTERING:

Optimal morphological [11] filtering is another type of filter, which is basicallyused for detection of impulsive noise. In this filtering technique the salt and pepper noise are reduced by replacing the median value with the noisy pixel of the image or by calculating the mean and median value of the neighbour the error pixel are calculated.

Due to additive quality that is calculation of neighbour pixel to calculate the noise pixel in image and make it noise free it is superior then median filter. But the advance version of the optimal morphological filtering is proposed morphological filtering.

This higher version of optimal morphological filtering technique was proposed by Md.M.Rahman et al. This technique is also used for reduction of impulsive noise. In this advance technique the noisy and noise free image are detected by using a mask over that corrupted image. The corrupted pixels are detected by evaluating the pixel value against the minimum and maximum value of the mask.

Let P denote noisy image, $p_{ij}$ is the centre pixel of an image and the neighbour of the image is as described in the table.

| | | |
|---|---|---|
| $P_{i-1\ j-1}$ | $P_{i-1\ j}$ | $P_{i-1\ j-1}$ |
| $P_{i\ j-1}$ | $P_{ij}$ | $P_{i\ j+1}$ |
| $P_{i+1\ j+1}$ | $P_{i+1\ j}$ | $P_{i+1\ j+1}$ |

$$PE=\left\{ \forall_{i=1}^{3} \forall_{j=1}^{3} \max(Pij \cup Pji) \right. \text{----------(1)}$$

$$SE=MAX\left\{ \forall_{i=1}^{3} \forall_{j=1}^{3} \min(Pij \cup Pji) \right. \text{----------(2)}$$

The equation(1) calculate the low intensity (pepper noise) by figuring the minimum of all row and column pixel in an image. The equation(2) compute the high intensity value (salt noise) by calculating the maximum of all row and column value of the noisy image.

Advantage: This method is very much good in preserving the fine detail such as line and corner of a grey scale image.

Disadvantage: This technique is not suitable for colour image.

**f. FUZZY FILTERING TECHINQUE:**

Fuzzy filtering technique or fuzzy logic [12] is most popular for removing Gaussian Noise from the corrupted grey scale image .This technique was proposed by Luo.

This type of technique is also good for removing impulsive and multiplicative Noise as well. This fuzzy technique based on deciding whether a pixel in an image is noise free or noise corrupted. If a pixel is finding out corrupted then this fuzzy technique is applied otherwise no smoothing operation is conducted on the noise free pixel to preserve the noise detail.

**This technique consists of two steps:**

1. Estimating the noise
2. Smoothing according to the noise level

Noise Estimation: The noise estimation technique is carried by byfuzey derivation estimation technique. In this technique an estimated table is produced for the noise detection of neighbouring pixel.

Table-2: Evaluation of fuzzy filtering technique

| | | |
|---|---|---|
| NW | N | NW |
| W | (x,y) | E |
| SW | S | SE |

Here a simple derivative of centre pixel is calculated by all possible direction. The idea behind the concept is that the derivative value terns higher due to the presence of noise.

If the two out of three derivative values are small, it is safe to consider no edge is present in the Consider direction.

Smoothing: The fuzzy technique for smoothing are as follow

1. If a pixel is darker then the neighbouring pixels then make that pixel brighter.
2. If a pixel is brighter then neighbouring pixels make the pixel darker.
3. Else leave the pixel error free.

Advantage: Fuzzy filter is an effective filter which can clear the noise completely from the image without making it blurry. The output image formed by fuzzy filter can enhanced according to the user requirement.

Disadvantage: This technique is very complex in nature.

**g . MULTIPLE THRESHOLD SWTCHING (MTS):**

Multiple threshold [13] switching is one of the most popular approaches to reduce the impulse noise in most efficient manner. This technique is proposed by Tzu.chao.lin. The MTS technique

based on finding the signal which is either noise free or noise corrupted. Ones the noise free and noise corrupted signal is found in an image, then it will be easy to filter the noise corrupted signal due to which noise free signal are not hampered by blurring or data loss.

The basic technique on this MTS is that only the noise corrupted pixel are replaced with the estimated central noise free ordered mean value. As a result an image with distinguished details and edges can be recovered.

The MTS filter is basically proposed to restore the images corrupted by salt-pepper impulse noise. The MTS filters uses multiple thresholds to classify the signal as either noise free or noise corrupted, so that only noise signal are filtered while noise free signal are preserved.

**h. BILATERAL FILTERING:**

Bilateral filtering [14] is another efficient approach for filtering noisy image. It is most popular due to its capacity of reducing noise while preserving the structural detail of the image. This technique of filtering method is very much efficient in medical image processing and non-destructive testing process.

The basic technology of bilateral filtering is that it is a combination of domain and range filtering. The domain filtering average the noisy pixel having the similar pixel value and act as a low pass filter. The range filter stands for the nonlinear components and plays an important part in edge preserving.

Bilateral filtering utilizes the spatial information and intensity information between a point and neighbours to smooth the noisy image.

**i.Wiener filter:**

Wiener filter [15] is another efficient approach for filtering of noise in an image. This technique is discussed by P.P.Patro and et al. In this type of filtering process a small filtering window is selected initially. Then the window size is changed or selected according to the amount of noise present in that picture which have to be noise free. Wiener filter is efficient for filtering of salt and pepper noise and Gaussian noise. Here also various masks having different size are used.

The wiener filter is expressed as

$$G(x,y) = \frac{H^*(x,y)}{H(x,y)^2 + \frac{S_n(x,y)}{S_f(x,y)}} \qquad 7$$

Here H(x,y) = Degradation function

$H^*(x,y)$ = complex conjugate of degradation function

$S_n(x,y)$ = Power spectral density of noise

$S_f(x,y)$ = Power spectral densityof un degraded Image

**Table 3: Summary of different techniques of noise reduction**

| Sl no. | Author | Year | Methodology | Conclusion | Future scope |
|---|---|---|---|---|---|
| 1 | P.KambojandVersha Rani [2] | 2013 | Median filtering | Easy to implement but when quantity of noise increase the median filter will not give good result | By applying median filtering technique a filter may be produce to give good result when the noise level is high. |
| 2 | K.Tewari [5] | 2012 | Adaptive Median filtering | De-noise the noisy pixel leaving the noise free pixel unchanged, but the possible edges of image is not taken into account | For preserving the edge of the image effective technique may be added. |
| 3 | S. Md. M.Roomi [6] | 2007 | Detail preserving filtering technique | It maintain higher peak to signal ratio (PSNR) to preserve the edge and noise ratio of a corrupted image but time consume to reduce the image is more | A method must be added to reduce the time consumed for de-noising the image. |

| | | | | | |
|---|---|---|---|---|---|
| 4 | P. H. Sangave [7] | 2006 | Tolerance based selective Arithmetic mean filtering technique | The proposed filter is good for grey scale image with difference noise model for salt and pepper noise, but this technique is not suitable for colour image | Some technique is add to make the technique suitable for reduction the noise from the colour image |
| 5 | M.Rahman [8] | 2012 | Optimal morphological filtering technique | This method is very much good in preserving the fine detail such as line and corner of a grey scale image, but this technique is not suitable for colour image | Some technique must be add to make the technique suitable for reduction the noise from the colour image |
| 6 | K.R. Babu [9] | 2011 | Fuzzy filtering technique | This technique is good for image preserving and smoothing but it is very complex in nature. | Some technique is added to reduce the complex in the process to reducing noise from the image. |
| 7 | Tzu.chao.lin [10] | 2006 | Multiple threshold switching | This technique is capable of filtering noisy signal while preserving the edge while it increases the complexity. | The complexity must be reduced by adding effective technique. |

| | | | | | |
|---|---|---|---|---|---|
| 8 | P.D.patil [11] | 2015 | Bilateral filtering | It is a combination of domain and range filtering while it only utilise the spatial information. | Some technique must be applied by which the technique most be comfortable in other ares. |
| 9 | P.P.Patro | 2015 | Wiener filter | This is a nonlinear type of filter and the window size is changed according to the change in noise density. | Some efficient technique must be use to reduce the blurring in image. |

**Table 4: Comparison table:**

| Sl no. | Methodology | Advantage | Disadvantage |
|---|---|---|---|
| 1 | Median filtering | Easy to implement | When quantity of noise increase the median filter will not give good result. |
| 2 | Adaptive Median filtering | De-noise the noisy pixel leaving the noise free pixel unchanged | The possible edges of image is not taken into account |
| 3 | Detail preserving filtering technique | maintain higher peak to signal ratio (PSNR) to preserve the edge and noise ratio of a corrupted image. | Time consumed to reduce the noise is more. |
| 4 | Tolerance based selective Arithmetic mean filtering technique | The proposed filter is good for grey scale image with difference noise model for salt and pepper noise | This technique is not suitable for colour image |
| 5 | Optimal morphological filtering technique | This method is very much good in preserving the fine detail such as line and | This technique is not suitable for colour image |

| | | | |
|---|---|---|---|
| | | corner of a grey scale image. | |
| 6 | Fuzzy filtering technique | This technique is good for image preserving and smoothing. | This technique is very complex in nature |
| 7 | Multiple threshold switching | This technique is capable of filtering noisy signal while preserving the edge. | It increases the complexity. |
| 8 | Bilateral filtering | It is a combination of domain and range filtering. | It only utilise the spatial information |
| 9 | Wiener filter | This technique is good for image preserving because mask size is choosen according to the noise level in the image. | The main disadvantage is this filter is that it produces blurring in image |

**4. Conclusion:** Here by analysing various techniques Multiples threshold switching and Bilateral filtering is the effective filtering process for reduction of noise in image. As Fuzzy filtering technique is good in filtering an image but it is very much complex in nature.

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