A Survey on Various Noises and Filtering Techniques

T.K.K.Praneeth
Department of Information Technology
Gudlavalleru Engineering College, Gudlavalleru, A.P, India

P.S.S.Sreedhar
Department of Information Technology
Gudlavalleru Engineering College, Gudlavalleru, A.P, India

M.Vamsi Krishna
Department of Information Technology
Gudlavalleru Engineering College, Gudlavalleru, A.P, India

Abstract- In image processing, noise reduction and restoration of image is expected to improve the qualitative inspection of an image and the performance criteria of quantitative image analysis techniques Digital image is inclined to a variety of noise which affects the quality of image. The main purpose of de-noising the image is to restore the detail of original image as much as possible. The criteria of the noise removal problem depends on the noise type by which the image is corrupting .In the field of reducing the image noise several type of linear and non linear filtering techniques have been proposed . Different approaches for reduction of noise and image enhancement have been considered, each of which has their own limitation and advantages.

Keywords – Digital Image Processing, Images Types, Image Noise Model, Filters

I. INTRODUCTION

Digital Image Processing is a component of digital signal processing .The area of digital image processing refers to dealing with digital images by means of a digital computer. Digital image processing has several advantages above analog image processing; it allows a considerably wider collection of algorithms to be apply to input data and can keep away from problems for instance the build-up of noise and signal deformation during processing. Digital Image Processing involves the modification of digital data for improving the image qualities with the aid of computer. The processing helps in maximize the clarity, sharpness of image and details of features of interest towards extraction of information & further analysis. Digital image processing is a very broad subject and it often involves the procedures which can be complex mathematically, but the central idea behind digital image processing is simple. The digital image is given as input into a computer and computer is programmed to change these data with the help of an equation, or with series of equations and then store the values of the computation for each pixel or picture element.

The results form a new digital image that may be display or it can be recorded in pictorial format or it may itself be further changed by additional computer programs. To enhance certain features in the data and to remove noise from image, the digital data is subjected to different image processing operations. Image processing involve changing the quality of an image in order to:

a. Improve the pictorial information of an image for human interpretation,
b. Render the image should be more suitable for independent machine perception.

The methods of Image-processing may be grouped into main three functional categories:

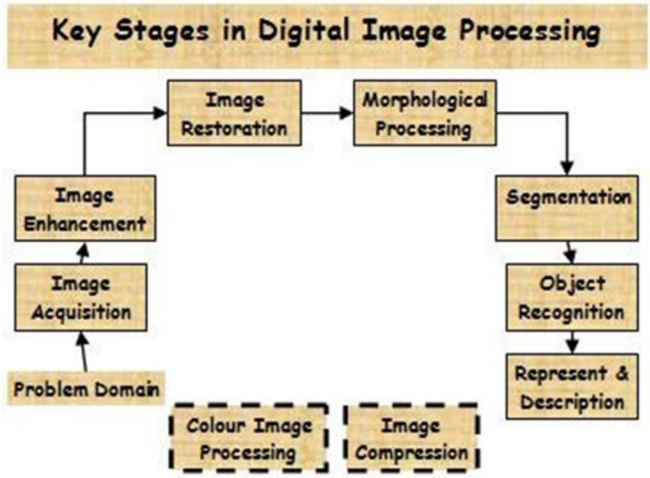

Figure. 1.1 Key Stages of Digital Image Processing

Image Restoration compensate for noise, data errors, and the geometric distortions that is introduced while recording, scanning, and the playback operations.

a. It restore the periodic line dropouts
b. Used for restoring periodic line striping
c. Good for filtering of random noise
d. Enhance geometric distortions

Image Enhancement: Processing an image so that the result is more suitable for a particular application. Such as sharpening or de-blurring an out of focus image, highlighting the edges of image , improving the contrast of image or increase the brightness level of an image, remove the noise from noisy image.

a. Used for Contrast Enhancement
b. Intensity, saturation and hue transformations
c. Edge enhancement
d. Producing the synthetic stereo image

Image Analysis: Image analysis is concerned with making a quantitative measurement from an image to produce a description of image. Image analysis techniques extract the certain features that aid in the recognition of an object. Quantitative measurement of an object features allow description and classification of the image.

a. Produce principal component images
b. Producing the ratio images
c. Multi-spectral classification
d. Produced change detection images

II. IMAGE AND ITS TYPES

An image may be well-defined such as a two-dimensional function F(a, b).Where a and b are spatial (plane) coordinate, and the amplitude of F at any pair of coordinates (a, b) is called the intensity or gray level of the image at that point. When a, b and the amplitude values of are all predetermined discrete quantity, we will call the image as digital image. A digital image is collection of a finite number of elements, in which each element has a certain value and location. These elements of digital image are known as image elements, picture elements, pels, and pixels. Pixel is the word mostly used refer to the elements of a digital image [1].

Types of Digital Images:

Binary: In binary image the value of each pixel is either **black** or **white**. The image have only two possible values for each pixel either 0 or 1, we need **one bit** per pixel.

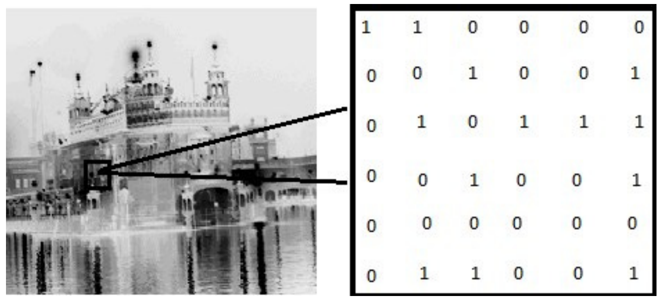

Figure. 1.2 Example of Binary Image ***Grayscale:*** In grayscale image each pixel is shade of gray, which have value normally **0** [black] to **255** [white]. This means that each pixel in this image can be shown by **eight bits**, that is exactly of **one byte**. Other grayscale ranges can be used, but usually they are also power of **2**.

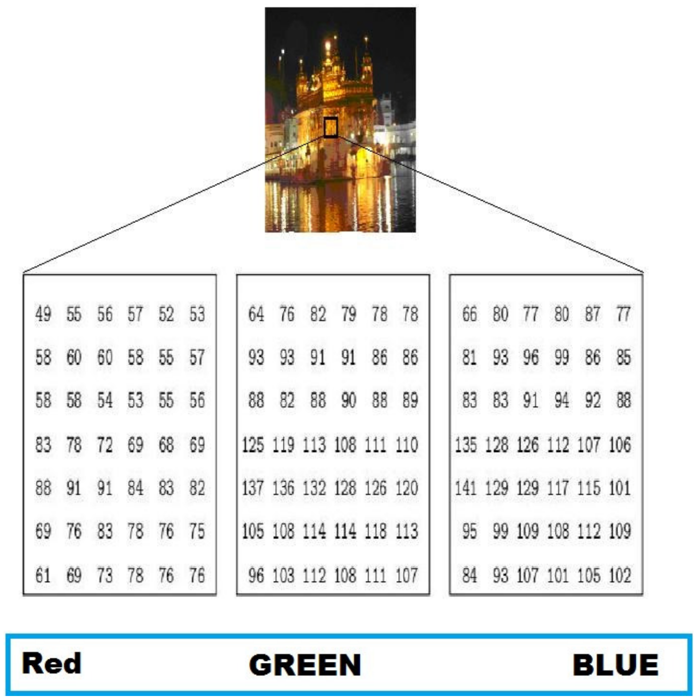

Figure. 1.4 Example of Color Image

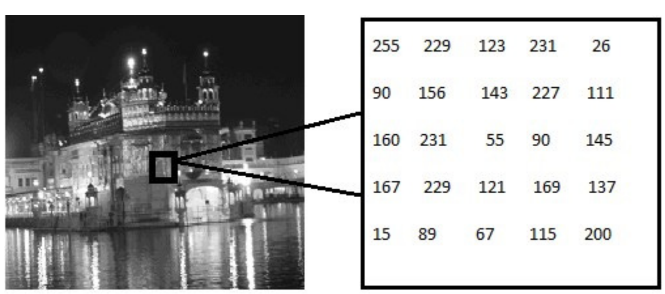

Figure. 1.3 Example of Grayscale

***True Color** or **RGB**:* Each pixel in the RGB image has a particular color; that color in the image is described by the quantity of **red**, **green** and **blue value in** image. If each of the components has a range from 0–255, this means that this gives a total of **2563** different possible colors values. That means such an image is “stack” of **three matrices**;

that represent the **red**, **green** and **blue** values in the image for each pixel. This way we can say that for every pixel in the RGB image there are corresponding 3 values.

Indexed: Mostly all the colors images have a subset of more than sixteen million possible colors. For ease of storage and handling of file, the image has an related color map, or we can say the colors palette, that is simply a list of all the colors which can be used in that image. Each pixel has a value associated with it but it does not give its color as for as we see in an RGB image. Instead it give an index to the color in map. It is convenient for an image if it has 256 colors or less. The index values will require only one byte to store each. Some image file formats such as GIF which allow 256 color only.

Digital Image File Types:

BMP:

Bmp stands for Bitmap. Every picture on a computer appear to be a BMP. In Windows XP the Paint program save its images automatically in bitmap format, however in Windows Vista images are saved now into JPEG format. Bitmap is the basis platform for many other file types.

Benefits: High quality image, Easy to change and edit, No loss in image through process

Downfalls: Difficulty while displayable on internet and large in file size.

JPG, JPEG:

JPEG stands for **Joint Photographic Experts Group** .Jpeg format is mainly used for color photographs. It is not good with sharp edges and it tends to blur the image a bit. This format became trendy with the innovation of the digital camera. Digital cameras mostly download photos to our computer as a Jpeg format. Digital camera manufacturers obviously see the value in high quality images that eventually take up less space.

Benefits: Small size image, easily viewable from internet,
Use millions of colors, and perfect for many type of images ***Downfalls:*** High compression loses quality of image, every time a JPG image is saved, it loses more and more quality of the picture.

GIF:

GIF stands for Graphics Interchange Format. This format is best suited for text, drawing line screen shots, animations and cartoons. Gif format is limited to total number of 256 colors or it can be less. It is mostly used for loading the fast web pages. It also help to makes great banner and logo for different webpage. Different type of animated pictures are saved in GIF format. For example, the flashing banner would be saved as a Gif file format.

Benefits: It is supported mostly by all web browsers, it is very small file size, Easy to load, Benefit for Transparencies, and animations and Image maps

Downfalls: We can used only basic colors, Complex pictures look horrible, No details of images are allowed.

PNG:

PNG stands for Portable Networks Graphic. This is one of the best image format, still it was not always well-suited with all web browsers and image software. This is the best image format to use for the website. It is also used for logo's and screen shots.

TIFF:

TIFF stands for Tagged Image File Format. This format has not been restructured since 1992 and is now owned by Adobe. It can store an image and data (tag) in the one file. This file is commonly used for scanning the data, faxing, word processing etc. It is no common file format that can be use with our digital photos.

Benefits: The image is perfect, Never loss any image.

Downfalls: Due to massive file size there is difficulty in transferring of the file, not able to view on the internet, only some specialized program can view it.

III. NOISE MODELS

The main source of noise in digital images arises during image acquisition (digitization) or during image transmission. The performance of image sensor is affected by variety of reasons such as environmental condition during image acquisition or by the quality of the sensing element themselves. For instance, during acquiring images with CCD camera, sensor temperature and light levels are major factors that affecting the amount of noise in the image after the resulting. Images are corrupted while during transmission of images. The principal reason of noise is due to interfering in the channel which is used for the images transmission [3].We can model a noisy image as follows:

$$C(x,y)=A(x,y)+B(x,y)$$

Where A(x ,y) is the original image pixel value and B(x ,y) is the noise in the image and C(x ,y) is the resulting noise image.

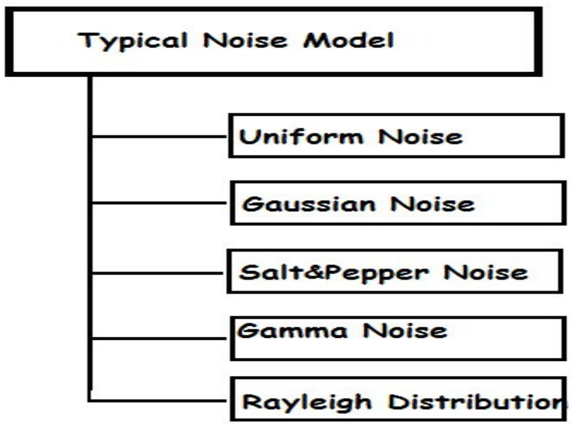

Figure. 1.5 Typical Noise Model Type

Uniform Noise:

The uniform noise cause by quantizing the pixels of image to a number of distinct levels is known as quantization noise. It has approximately uniform distribution. In the uniform noise the level of the gray values of the noise are uniformly distributed across a specified range. Uniform noise can be used to generate any different type of noise distribution. This noise is often used to degrade images for the evaluation of image restoration algorithms. This noise provides the most neutral or unbiased noise

Uniform noise:

$$p(z)=\begin{cases}\frac{1}{(b-a)} & \text{if } a\le z\le b\\ 0 & \text{otherwise}\end{cases}$$

$$\mu=(a+b)/2; \qquad \sigma^2=(b-a)^2/12$$

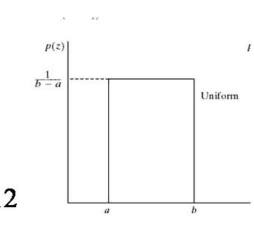

Figure. 1.6 PDF, mean, variance of uniform noise

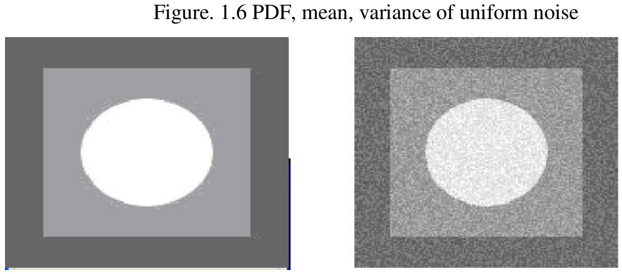

Figure. 1.7 Example of Uniform Noise

Gaussian

Noise or Amplifier Noise:

This noise has a probability density function [pdf] of the normal distribution. It is also known as Gaussian distribution. It is a major part of the read noise of an image sensor that is of the constant level of noise in the dark areas of the image.

Gaussian noise:

$$p(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-(z-\mu)^2/2\sigma^2}$$

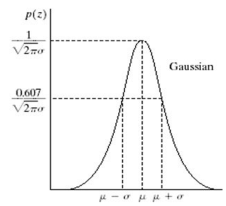

Figure. 1.8 PDF of Gaussian Noise

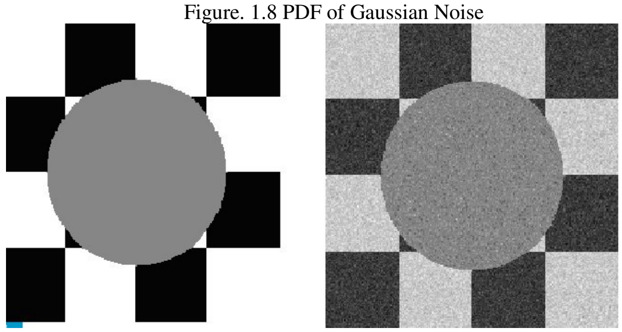

Figure. 1.9 Example of Gaussian Noise

Salt and Pepper Noise:

The salt-and-pepper noise are also called shot noise, impulse noise or spike noise that is usually caused by faulty memory locations ,malfunctioning pixel elements in the camera sensors, or there can be timing errors in the process of digitization .In the salt and pepper noise there are only two possible values exists that is a and b and the probability of each is less than 0.2.If the numbers greater than this numbers the noise will swamp out image. For 8-bit image the typical value for 255 for salt-noise and pepper noise is 0 ***Reasons for Salt and Pepper Noise:***

a. By memory cell failure.
b. By malfunctioning of camera's sensor cells.
c. By synchronization errors in image digitizing or transmission.

Impulse noise:

$$p(z) = \begin{cases} P_a & for \quad z = a \\ P_b & for \quad z = b \\ 0 & otherwise \end{cases}$$

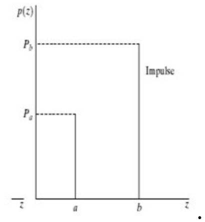

Figure. 1.10 PDF of Impulse Noise

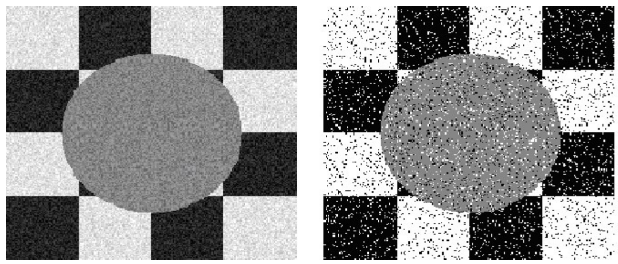

Figure. 1.11 Example of Impulse Noise

Rayleigh Noise:

Radar range and velocity images typically contain noise that can be modeled by the Rayleigh distribution.

Rayleigh noise:

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

$$\mu = a + \sqrt{\pi b/4}; \qquad \sigma^2 = \frac{b(4-\mu)}{4}$$

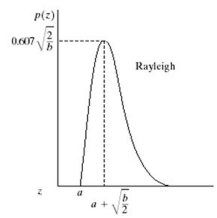

Figure. 1.12 PDF, Mean, Variance of Rayleigh Noise

Gamma Noise:

The noise can be obtained by the low-pass filtering of laser based images

Erlang (Gamma) noise:

$$p(z) = \begin{cases} \frac{a^b z^{b-1}}{(b-1)!}e^{-az} & for \quad z \geq 0 \\ 0 & for \quad z < 0 \end{cases}$$

$$\mu = b/a; \qquad \sigma^2 = b/a^2$$

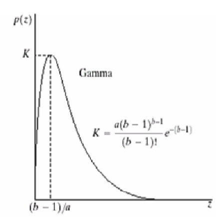

Figure. 1.13 PDF, Mean, Variance of Gamma Noise

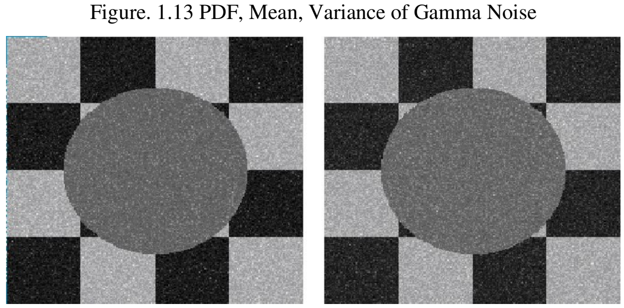

Figure. 1.14 Example of Rayleigh Noise and Gamma Noise

IV. FILTERS

Filtering in an image processing is a basis function that is used to achieve many tasks such as noise reduction, interpolation, and re-sampling. Filtering image data is a standard process used in almost all image processing systems. The choice of filter is determined by the nature of the task performed by filter and behavior and type of the data. Filters are used to remove noise from digital image while keeping the details of image preserved is an necessary part of image processing. Filters can be described by different categories:--

Filtering without Detection:

In this filtering there is a window mask which is moved across the observed image. This mask is usually of the size $(2N+1)/2$, in which N is a any positive integer. In this the centre element is the pixel of concern. When the mask is start moving from left top corner to the right bottom corner of the image, it perform some arithmetic operations without discriminating any pixel of image

Detection followed by Filtering:

This filtering involves two steps. In the first step it identify the noisy pixels of image and in second step it filters those pixels of image which contain noise. In this filtering also there is a mask which is moved across the image. It performs some arithmetic operations to detect the noisy pixels of image. Then the filtering operation is performed only on those pixels of image which are found to be noisy in the first step, keeping the non-noisy pixel of image intact.

Hybrid Filtering:

In hybrid filtering scheme, two or more filters are used to filter a corrupted location of a noisy image. The decision to apply a particular filter is based on the noise level of noisy image at the test pixel location and the performance of the filter which is used on a filtering mask.

Filter Description:

g(x, y)=Corrupted image f(x ,y)=Filtered image ***Filtering Techniques:***

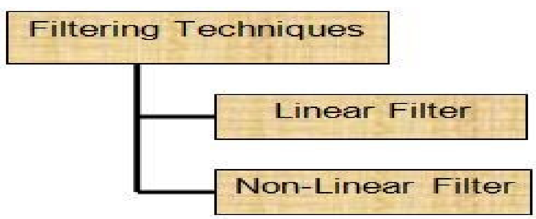

Figure. 1.15 Techniques of Filtering ***Linear Filters:***

Linear filters are used to remove certain type of noise. Gaussian or Averaging filters are suitable for this purpose. These filters also tend to blur the sharp edges, destroy the lines and other fine details of image, and perform badly in the presence of signal dependent noise[5].

Non-Linear Filters:

In recent years, a variety of non-linear median type filters such as rank conditioned, weighted median, relaxed median, rank selection have been developed to overcome the shortcoming of linear filter.

Different Type of Linear and Non-Linear Filters:

Mean Filter: The mean filter is a simple spatial filter .It is a sliding-window filter that replace the center value in the window. It replaces with the average mean of all the pixel values in the kernel or window. The window is usually square but it can be of any shape.

Unfiltered Values		
8	4	7
2	1	9
5	3	6

8+4+7+2+1+9+5+3+6=45
45 / 9 = 5

Figure. 1.16 An Example of mean filtering of a 3x3 kernel of values is shown below

Mean filtered		
*	*	*
*	5	*
*	*	*

Figure. 1.17 In this Center value which is previously 1 in the unfiltered value is replaced by the mean of all nine values that is 5.

Advantage:

a. Easy to implement
b. Used to remove the impulse noise.

Disadvantage*:* It does not preserve details of image. Some details are removes of image with using the mean filter.

Median Filter:

Median[4] Filter is a simple and powerful non-linear filter which is based order statistics. It is easy to implement method of smoothing images. Median filter is used for reducing the amount of intensity variation between one pixel and the other pixel. In this filter, we do not replace the pixel value of image with the mean of all neighboring pixel values, we replaces it with the median value. Then the median is calculated by first sorting all the pixel values into ascending order and then replace the pixel being calculated with the middle pixel value. If the neighboring pixel of image which is to be consider contain an even numbers of pixels, than the average of the two middle pixel values is used to replace. The median filter 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 best result.

	10	5	20				
	14	80	11				
	8	3	22				

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

↑

median (central value 80 is replaced by 11)

Figure. 1.18 Method of Median Filter ***Algorithm of Median Filter:***

The algorithm for the median filter is as follows:

Step 1. Select a two dimensional window W of size 3*3. Assume hat the pixel being processed is Cx,y. Step 2. Compute Wmed the median of the pixel values in window W.
Step 3. Replace Cx,y by Wmed.
Step 4. Repeat steps 1 to 3 until all the pixels in the entire image are processed.

Advantage:

a. It is easy to implement.
b. Used for de-noising different types of noises.

Disadvantage:

a. Median Filter tends to remove image details while reducing noise such as thin lines and corners.
b. Median filtering performance is not satisfactory in case of signal dependant noise. To remove these difficulties different variations of median filters have been developed for the better results.

Wiener Filter:

The purpose of the Wiener filter is to filter out the noise that has corrupted a signal. This filter is based on a statistical approach. Mostly all the filters are designed for a desired frequency response. Wiener filter deal with the filtering of an image from a different view. The goal of wiener filter is reduced the mean square error as much as possible. This filter is capable of reducing the noise and degrading function. One method that we assume we have knowledge of the spectral property of the noise and original signal. We used the Linear Time Invariant filter which gives output similar as to the original signal as much possible [4].
Characteristics of the wiener filter are [6]:

a. Assumption: signal and the additive noise are stationary linear-random processes with their known spectral characteristics.
b. Requirement: the wiener filter must be physically realizable, or it can be either causal
c. Performance Criteria: There is minimum meansquare[MSE] error.

The Fourier domain of the Wiener filter is

$$G(u,v) = \frac{H^*(u,v)}{\left|H(u,v)\right|^2 P_s(u,v) + P_n(u,v)}$$

Where *H*(u, v)* = Complex conjugate of degradation function
Pn (u, v) = Power Spectral Density of Noise
Ps (u, v) = Power Spectral Density of non-degraded image *H (u, v)* = Degradation function

PERFORMANCE PARAMETERS

For comparing original image and uncompressed image, we calculate following parameters:

Mean Square Error (MSE): The MSE is the cumulative square error between the encoded and the original image defined by:

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2$$

Where, f is the original image and g is the uncompressed image. The dimension of the images is m x n. Thus MSE should be as low as possible for effective compression.

Peak signal to Noise ratio (PSNR): PSNR is the ratio between maximum possible power of a signal and the power of distorting noise which affects the quality of its representation. It is defined by:

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right)$$

Where MAX_f is the maximum signal value that exists in our original “known to be good” image.

Bit Per Pixel (BPP): It is defined as number of bits required to compress each pixel. It should be low to reduce storage requirement.

Signal to Noise Ratio is defined by the power ratio between a signal and the background noise.

$$\mathrm{SNR} = \frac{P_{\mathrm{signal}}}{P_{\mathrm{noise}}},$$

Where *P* is average power. Both noise and power must be measured at the same points in a system, and within system with same bandwidth.

V. CONCLUSION

Enhancement of an noisy image is necessary task in digital image processing. Filters are used best for removing noise from the images. In this paper we describe various type of noise models and filters techniques. Filters techniques are divided into two parts linear and non-linear techniques. After studying linear and non-linear filter each of have limitations and advantages. In the hybrid filtering schemes, there are two or more filters are recommended to filter a corrupted location .The decision to apply a which particular filter is based on the different noise level at the different test pixel location or performance of the filter scheme on a filtering mask.

REFERENCES

[1] K. Jain, “Fundamentals of Digital Image Processing”, Prentice Hall of India, First Edition, 1989.
[2] Rafael C .Gonzalez and Richard E. woods, “Digital Image Processing”, Pearson Education, Second Edition, 2005
[3] K. S. Srinivasan and D. Ebenezer, “A New Fast and Efficient Decision-Based Algorithm for Removal of High-
[4] Density Impulse Noises,” IEEE Signal Processing Letters, Vol. 14, No. 3, March 2007.
[5] H. Hwang and R. A. Haddad”Adaptive Median Filters: New Algorithms and Results” IEEE Transactions on image processing vol 4. P.no 499-502, Apr 1995.
[6] Nachtegael, M, Schulte, S, Vander Weken. Kerre, E.E.2005.Fuzzy Filters for Noise Reduction: The Case of Gaussian Noise. IEEE Xplore, 201-206 D, De Witte. V, 206.
[7] Suresh Kumar, Papendra Kumar, Manoj Gupta, Ashok Kumar Nagawat, “Performance Comparison of Median and Wiener Filter in Image De-noising” ,International Journal of Computer Applications (0975 – 8887) Volume 12– No.4, November 2010.