CHAPTER-1
INTRODUCTION

Digital Image Processing is a promising zone of research in the fields of electronics and statement manufacturing, consumer and amusement electronics, organize and instrumentation, biomedical arrangement, remote sensing, robotics and processor view and computer aid in manufacturing (CAM). For a thoughtful and useful Dispensation such as image fragmentation and aim recognition, and to have high-quality legible display in applications similar to television, picture-phone, etc., Got image signal must be de blurred and made noise free. The de vague and shout suppression (filtering) come beneath a common class of picture Dispensation work known as picture restoration.

The a lot of noise condition is studied and many capacity nonlinear and adaptive digital image filter is designed to check additive white Gaussian noise (AWGN), bipolar permanent-valued impulse noise, also called salt and pepper noise (SPN), random-valued impulse noise (RVIN) and mixed noise (MN) reasonable effectively. The industrial filters are compulsory for online and real-time applications as television, photo-cell, etc.

The following topics are covered in this introductory chapter.

- Fundamentals of Digital Image Processing
- Noise in Digital Images
- Study of Image Filters Reported in the Literature
- Problem Statement
- Image Metrics
- Noise Conditions for Computer Simulation

1.1 Fundamentals of Digital Image Processing

Digital image processing normally change to the dispensation of a 2-dimensional (2-D) picture signal by a digital hardware. In a large context, it imply dispensation of any signal using a assign hardware, e.g. an accounting for specific integrated circuit (ASIC) or using a general-aim computer achieved some algorithms developed for the aim. An image is a 2-D role (signal),X (m,n), where m and n are the plane coordinates. The magnitude of X at any accumulate of coordinates (m,n) are the abandon or gray level of the image is at the point. In a digital image, m,n, and the magnitude of X is all confined and separate quantities. Each element of this matrix (2-D array) is called pixel [2].It is a hard task to analyze between the domains of image dispensation and other related zone such as computer vision. Though, essentially not right, image dispensation may be defined as a procedure where both input and output are images. At high level of processing and after some advance processing, it is ordinary to perform some analysis, judgment or decision made to perform some mechanical operation (robot motion). These zone is the domain of artificial intelligence (AI), computer vision, robotics, etc.

Digital image dispensation has a large after image of applications, such as digital television, photo-cell, remote sensing, the transfer of the image, and retain for applications small businesses , medical and processing, radar and sonar , and acoustic exemption picture , robots, and computer aided manufacturing (CAM) and automated quality control in industry. Fig. 1.1 depicts a typical image processing scheme.[1]

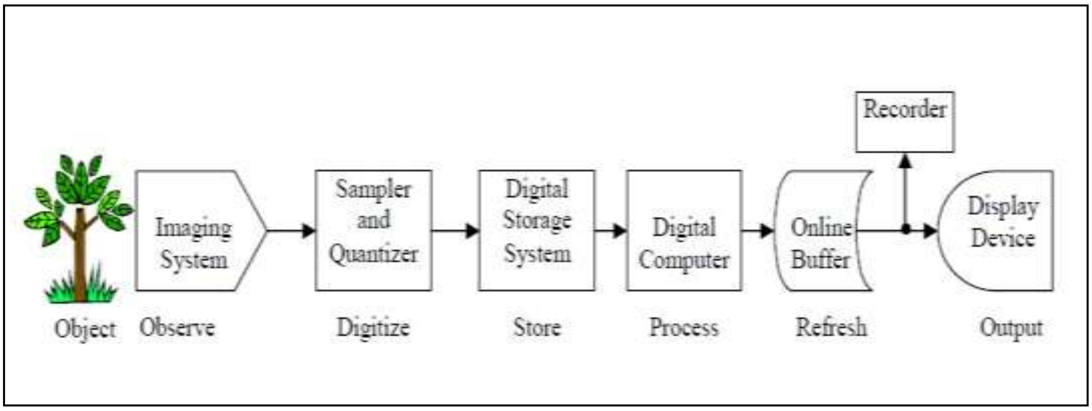

Fig.1.1 A typical digital image processing system

With the abnormal image acceptance and display, most of the image dispensationrole are achieve in software. A significant quantity of basic image dispensation software is accept commercially. Major zone of dispensatione processing are:

Image Presentation and Modelling

a) Image Transform
b) Image Enhancement
c) Image Analysis and Recognition

d) Image Reconstruction

e) Image Data Compression

f) Colure age Processing, etc

Image processing may be worked in the spatial field or in a transform area. To perform a thoughtful and useful work , a fitting transformer, example as discrete Fourier transform (DFT) , discrete cosine transform (DCT) , discrete wavelet transform (DWT) , etc. , maybe in employment. Base on the application, a fitting renovate is using. Image advancement technique is used to highlight to certain features of interest in a picture. Two important examples of an image advancement are (i) increasing the contrast, and (ii) changing the brightness of an image to the visible level so that the image looks clean. It is a subjective zone of an image processing. On the other way , image restoring is very much objective. The restoration techniques are totally based on mathematical and statistical admirable of image deprivation. De noising (filtering) and de vague working come in this category. Image dispensation is abnormal Before specific solutions, where a technique that works well in one region may be enough in the last [2] . The ideal solution for a specific problem has yet to make a big research and development. 'Image restoration and clearing' is one of the prime zones of picture processing to its objective is recover the picture from degraded acceptance. The techniques adorned in image restoration and clearing is oriented across modelling , the degradations and allot an inverse approach to found an estimate of the real picture. There is a lot of type of imaging systems . X-rays , gamma rays , ultraviolet radiation , and systematize ultrasound used in biomedical devices . And astronomy, and ultraviolet and infrared imaging radio systemic use. And it worked geological analysis of sonic imagery. microwave imaging radar vigilance in the work. But , the most well known imaging systems are lighting readable image. These systems use vigilance such as remote sensing , microscopy , measurements, and electronics customers, and electronics and entertainment , etc. An image get visual means, and is likely to appreciate the environment degraded by visual or electronic and electrical means. Phlegmatic will be in the form of sound sensor , because of the mysterious lady camera focus, the relative motion of the object from the camera, and turbulence in the atmosphere aimlessly , and so on. The noise in a picture may be due to a loud channels if the picture is transmitted through a average. It may also be due to electronic noising associated with a storage-retrieval arrangement.

Noise in an image is an important problem. The noise possibly will be AWGN, SPN, RVIN, or a mixed noise. Effective repression of noise in a picture is a very serious issue. De noising searches extensive applications in lots of fields of picture dispensation. Conventional techniques of picture Removed noising used linear and nonlinear techniques have previously been reported and enough literatures are available in this zone and has been reviewed in the after that division. Recently, different nonlinear and the adaptive filters have been not compulsory for the purpose. The objectives of this scheme are to decrease noise as well as to keep hold of the edges and search in formation of the unique picture in the restored picture as much as possible. However, both the objectives conflict each other and the reporting schemes are not able to perform acceptably in together aspects. Hence, still different search workers are actively busy in developing superior filtering schemes using latest signal dispensationtechniques. In the present thesis, efforts have been made in developing some efficient noise removed schemes.

1.2 Noise in Digital Images

In this segment, a choice of types of noise demeaning an image signal are calculated; the sources of noise are discussed, and mathematical models for the various types of noise are presented. An image signal gets corrupted with noise for the period of acquisition, transmission, storage and retrieval processes. Acquisition noise is generally additive white Gaussian noise (AWGN) with very low difference. In many engineering applications, the acquisition noise is quite negligible. It is due to very high quality sensors. In some applications similar to remote sensing, biomedical instrumentation, etc., the acquisition noise may be very sufficient. But in this type of system, it is generally because of the image acquisition system itself comprised of a transmission channel. So if such noise problems are measured as transmission noise, then it is possibly concluded that acquisition noise is tiny. The acquisition noise is considered negligible due to other fact that the human visual system (HVS) can’t identify a large dynamic range of image, because of this an image is generally quantized at 256 levels. So, every pixel is represented by 8 bits (1 byte). The present-day technology present very high quality sensors that do not have noise level greater than half of the determination of the analog-to-digital converter (ADC), i.e., noise magnitude in time domain, n(t) , where n(t) is the noise amplitude at any logical instant of time t, and V is the maximum output of the sensor and it is also equivalent to the maximum allowed input voltage level for the Analog-to-Digital Converter. The noise amplitude should be lesser than 6.5 mV. In various practical applications, the acquisition noise level is much lower than this margin. So, the acquisition noise will not be considered. That is why; the researchers are generally concerned with the noise in a transmission system. Commonly, the transmission channel is linear, but dispersive because of a limited bandwidth. The image signal may be transmitted also in analog form or in digital form.

If an analog image signal is transmitted from end to end in a linear dispersive channel, then the image edges (step-like or pulse like signal) will blurred and the image signal will contaminated with Additive White Gaussian Noise(AWGN).As no practical channel is noise free. If the channel is very poor that the noise variance is very high enough to make the signal excurse to high positive or high negative value, so the threes holding process is done at the face end of the receiver will contribute to saturated maximum and minimum values. Such noisy pixels will be shown as white and black spots. That is why; this type of noise is said as salt and pepper noise (SPN). In this case, if analog image signal is transmitted, then the signal will corrupted with AWGN and SPN respectively. So, there is an effect of the mixed noise. If the image signal is transmitted in digital through a linear dispersive channel, then inter symbol interference (ISI) will takes place. In addition, the presence of AWGN in the practical channel cannot be ignored. It will make the situation worse. Because of ISI and AWGN, it may be so happen that a ‘1’ may be recognized as ‘0’ and vice-versa. Under such conditions, the image pixel values have changed to the some random values at random positions in image frame. This type of noise is known as random-valued impulse noise (RVIN).

The AWGN, SPN, and RVIN is mathematical represented below. The Gaussian noise is given by,

$$\mathrm{n}_{\mathrm{AWGN}}(\mathrm{t})=\eta_{\mathrm{G}}(\mathrm{t}) \tag{1.1}$$

$$X_{AWGN}(m,n)=X(m,n)+\eta_G(m,n) \tag{1.2}$$

Where, η G (t) is a random variab1e that have a Gaussian probabi1ity distribution. It is an additive noise that is characterized by its variance, σ 2, where, σ presents its standard deviation. In (1.2), noisy image XAWGN is represented as a sum of the origina1 uncorrupted picture and the Gaussian distributed random noise η G. When variance of the random noise η G is very low, η G (m, n) is very close to zero or zero at many pixe1 locations. Under such conditions, the noisy image XAWGN (m, n) is similar or very close to the real picture X(m, n) at many pixel locations (m, n) . Let a digital picture X (m,n), after being corrupted with Salt and Peeper Noise of density d, which is represented by X SPN(m,n). Then, the noisy picture X SPN (m,n) is mathematically represented as:

$$X_{SPN}(\mathrm{m,n})=\begin{cases} X(m,n) with probability, & p=1-d \\ 0 & p={}^{d}/_{2} \\ 1 & p={}^{d}/_{2} \end{cases} \tag{1.3}$$

The impulse noise occurs at the random locations (m, n) with probability of d. The SPN and RVIN are substitutive in nature. A digital picture corrupted with RVIN of density d, $\mathbf{X}_{\mathrm{RVIN}}$(m,n), is mathematically represented as:

$$X_{RVIN}(\mathrm{m,n})=\begin{cases} X\,(m,n), with\ probability & p=1-d \\ \eta(m,n),\ \ with\ probability & p=d \end{cases} \tag{1.4}$$

Were, η (m, n) represents the uniformly distributed random variable, range from 0 to 1, that replace the original pixel value **X** (m,n). The noise level at any noisy pixel location (m,n) is independent of the original pixel level. Therefore, RVIN is truly substitutive. Other type of noise that may corrupt an picture signal is the Speckle Noise (SN). In some of the biomedical applications as ultrasonic imaging and some engineering applications as the Synthesis Aperture Radar imaging, such noise is encountered. The Speckle Noise is a signal dependent noise, i.e., if the picture pixel magnitude will high, then the noise will also high. So, it is also known as multiplicative noise and is represented as,

$$n_{SN}(t)=\eta(t).S(t) \tag{1.5}$$

$$X_{SN}(m,n)=X(m,n)+\eta(m,n).X(m,n) \tag{1.6}$$

Here, η (t) is a random variable and S(t) is the magnitude of the signal. The noisy digital image, $X_{SN}(m,n)$, is represented mathematically in (1.6). The noise is multiplicative since the imaging system transmits a signal to the object and reflected signal is recorded. In the forward transmission channel, the signal will contaminated with additive noise in the channel. Because of varying reflectance of surface of the object, the reflected signal magnitude will vary. Therefore, also the noise will vary since the noise is also reflected by the surface of the object. Noise magnitude is, so, more when the signal magnitude is more. Therefore, the speckle noise is multiplicative in the nature. The speckle noise is encountered only in the few applications as ultrasonic imaging and SAR, while all other types of the noise i.e., AWGN, SPN, and RVIN occur in almost all of the applications. The AWGN is the most common among all. Under the very low noise variance it may looks like RVIN. In general, some combinations of AWGN, SPN, and RVIN should represent a practical noise. [3]

1.3 Study of Image Filters

All of the following topics are covered in this section

a) An Overview of the Digital Image Filters
b) A Critical Analysis in the Recent Development

1.3.1 An Overview of the Digital Image Filters

The linear filters were primary too1s in signa1 and image dispensation. A linear filter may be represented by mathematically by using a linear operator f(.) that shows an input signal, X into an output signal, Y as:

$$\mathbf{Y} = f(x) \qquad 1.7$$

The operator f(.) satisfied the superposition ideology. Because of the mathematical simplicity of the linear filters, this is very easy to design and implement them. However, filters and linear performance is very low in the presence of noise that are not additive , as well as in systems where they confronted the regime , such as non- linear and non-Gaussian statistics. linear filters tend to blur the edges, remove noise will not rush

Indeed, and will not perform well in the presence of the noise signal depends . To overcome these defects , it is proposed different types of non-linear filters in the literature. Such filters

,the operator f(.), is described in (1.7), and is not a linear function. Different families of the nonlinear filters having different characterization are studied. Most of currently available picture- dispensation software packages which include nonlinear filters. The most popular nonlinear filter is the median (MED) filter. It is computationally efficient, but yields blurred and the distorted outputs have been proposed a 2-D median filtering that is based on the arrangement and updating gray 1evel histogram of image elements in the window. Then, It was reported in the fast algorithm for real-time median filtering of signals and images. In this way, based on the noise in the filter and the local average contrast additive and multiplicative cases proposed . Recently it has been shown that the use of local statistics , which is more effective in removing the white noise and the additional multiplier. Therefore, it is not suitable for the removal of impulse noise because it uses the optimal linear approximation [4] .

It has been reported for other effective noise filtering algorithm that requires no modeling of the image of the two issues and the added noise multiplier for . Some of the features of the statistical analysis in the Mediterranean filters. MED and show that the candidate can remove the motivation and low contrast Gaussian noise have proposed a new line of attack of removing the impulse noise from pictures using the mean filter. These filtering proposals are based as replacing the central pixel va1ue in the common mean of a1l image pixels inside the sliding window. There are possibilities in the noise alienation The increase , which reduces its performance with the same fixed Mediterranean candidate. On the way , if the positive and negative effects on both the pattern is present type , the performance of even ordinary candidate is unacceptable. These filters are also not unchanged for simultaneous amputation of impulsive and non-impulsive noises. It was reported in article the nonlinear filter based on nonlinear mean works well under additive and impulsive noise assuage. This performance in the being thereof signal dependence Noise is a disease. It is known that the new nonlinear filter class for the image processing also reported statistics system (OS) candidate. This filter is generally used to reduce the white noise, and the noise based on the signal , noise and impulsive. It is known another candidate, as a reference to suit the edge of the Mediterranean candidate who achieves the best non-linear adaptive filters , and various other types of noise . Filter adaptation Average workers proposed is shows rough performance in the actions of impulsive noise and did not remove noise close to the corner. The filter scheme was proposed is can’t smother the impulsive noise adequate, but could preserve corner better than the mean filter. It will claim this decision-based on order statistics filters could reduce both an impulsive and non-impulsive noise can also enhance vague edges are better than many of the other OS filters. An adaptive filtering algorithm is the class of stack filter has proposed. An adaptive neural filter removes a lot of kinds of noise is as Gaussian noise and impulsive noise. An adaptive median filter has also been proposed for removed impulse noise and preserving image sharpness. Both filters are: Rank-order based adaptive median filter (RAMF), and size based adaptive median filter (SAMF). The fuzzy operator had suggested in enhancement of vague and noisy picture. A new achieves to spatial and an Storing the image on adaptation, which employs the minimum additional computational load compared with direct techniques have been proposed. The uses of the wavelet transform presents a new method for storing and adapt to very good yields in the corner to keep the stored images . New algorithm to remove noise batch of images and also offers adapted nature of the liquidation process of the adaptable state. Keys and is an algorithm of the workbook that refers to providing and paying the corruption before operating on absolute ranked accommodation with a sliding window. That techniques are significantly outclass the A number of techniques are known in the presence of impulsive type and a mixed Gaussian noise. reliable and efficient calculation algorithm has been proposed for the storage of a mysterious image and noisy using an inverse filtering technique images can be stored mysterious . In a recent publication . has suggested a unified achieve for a noise and removal, image enhancement, and shape come about. That achieve relies are the Writing a set of curves and the movement of the head at the surface to a class of partial differential equations of the algorithm based . Improved medical images may be the approach and arrival of the technology. Several medium and at least adapt Square (LMS) filter has also proposed for the noise suppression from an images.

The robust achieve to an image enhancement based on the fuzzy and logics have been proposed to that achieve used weight least square mistake criteria for a selecting the filtering. The new methods of multi-dimensional median filters are presented. These methods employ to reduce the vector median filter (RVMF) to vector data. It may apply to a colored images and offered satisfactory performance. The fast algorithm is called 1-Norm vector median filter was shown for a filtering of a natural images were corrupted by a spike noise. This algorithm was computationally an efficient. Provides statistics candidate for adaptation to gamma rays to damage the image sequence. Show this technique to adjust the weight of the estimator that adjust the probability density function of the noise statistics . This approach is very successful in managing the noise signal depends . You can also remove the pulsating noise by using high-level statistics. However, this technique requires a higher statistical account of the conditions , which is computationally expensive . Clean impulse noise is also performed using Artificial Neural Network (ANN). It is observed that a single layer neural network accurately find the impulse noise of fixed amplitude. Therefore, it does not perform well in terms of random-valued impulse noise. A plethora of nonlinear and the adaptive filtering schemes can be found in literature. Lots of them are simply some variants are familiar to the MED filter. The disadvantages of these filters are their computational complexities.

For most typical applications, picture noise can be modeled with Gaussian, uniform, or impulsive distribution. Gaussian noise may be analytically explained and its probability density function has a characteristic of bell shape. In the The uniform distribution , and level of noise gray values are divided equally certain level. Impulse noise generates pixels with gray level values which are not in accordance with the local neighborhood . In the presence of impulsive noise , linear filters that work with the convolution fixed image with a matrix to create a linear combination of the neighborhood pixel values exhibit very poor performance and produce blurred and distorted the image output. Generally used nonlinear MED filter that is implemented within the picture even if it is computational1y efficient, suppresses impulse noise, and preserves edges, it reduce desirable information in the restored pictures. For the best performance , in a different environment on the basis of generalized and modified filter was suggested as a filter medium multistage (MSM) candidate , the weighted average center (CWM)and the stack filter. These methods generally produce good results at the low noise conditions, but the performance deteriorates as the noise density increases. One more possible The solution is to use a filter that is able to identify the pixel noise contaminated before cleaning and allow the unchanged without noise pixel. This was suggested on the basis of the decision taken by the candidates Mediterranean threshold operations in the literature. Many of them carry the same level with the centrist candidate , in a while, the performance of others is even better. But as the noise of increasing intensity and their performance also becomes lower. [5]

Similarly, removal of Gaussian noise from the pictures is also a major problem in the real world and the attempts have been made for developing the new efficient methods for this reason. Discrete Wavelet Transform (DWT) based schemes by using threes holding is representative example for restore signals and pictures from their noisy models. A novel approach, which is called ANN-threshold filtering scheme, has been offered by Zhang. It is an adaptive filter. Since it is based on the neural network, it requires training. That is why; it is a computational-intensive scheme. The concepts of fuzzy logic have revolutionized the research and the development in the zones like signal processing, control, and the instrumentation, etc. Many researchers have used fuzzy logic to develop efficient picture filters. Neural network is a other important tool used in the signal processing. Many of neural networks based on the noise detectors and noise filters are proposed in the literature. A novel impulse detection scheme is offered by Panda et al..Discrete Wavelet Transform (DWT) is very powerful signal analysis tool. Many researchers have used DWT to design efficient digital picture filters.

1.3.2 A Critical Analysis on the Recent Development

The minimum and maximum exclusive mean (MMEM) is developed which shows a very good performance in suppressing SPN of the high density. It first considers 3×3 windows and rejects the pixels in very high and the very low ranges. If nothing more option is left, then the window size is increased by 5×5 and same type of the operation is performed. Doesn't matter what pixels are left; apart from the very high-valued and the very low-valued pixels, only these pixels are considered and their average values are calculated. If the average value is differs from center pixel value by more than a threshold level at that time the filter takes a decision to replace the center pixel with the average value; or else the filter keeps the original center pixel values. It might look like a decision-directed ROM filter. But, it is not so. The filtering algorithm is a bit differing from the simple ROM. Table1.1 which shows the performance of the MMEM filter and the other standard filters for the comparison purposes. The above table gives a very serious result. So the authors claim that the decision-directed filter, MMEM, is very efficient, this shows slightly very poor performance at low SPN density as compared to the SD-ROM filter. This is very important to visualize for a designer. Any system which does work fine at one extreme end of input type does not work so well at the other extreme end. So, there is a scope to examine and develop the very good image filters to suppress the low-density impulse noise. Which have developed a nonlinear filter that is average (TSM) candidate - three states called to save the image of the details while the effectiveness of the removal of impulsive noise. average candidate standard (MED) and the center of the weighted average filter (CWM) are in businesses in the context of the noise detection to study whether the pixels damage before applying the appointment process. Approach presented combines the advantages of fuzzy models and nervousness. network architecture is designed to fully exploit the efficiency of fuzzy logic to suppress noise without destroying the useful information embedded in data entry . The approach is able to automatic gain knowledge of a particular network has been suggested fuzzy logic filter for picture enhancement. This is able to remove the impulse noise and the smooth Gaussian noise. Therefore also, it preserves edges and the image details. While it is claimed that this filter suppresses the mixed noise quite effectively, the MSE at the output of this filter decreases to 0.0045 for the input mixed noise of AWGN ($\sigma 2=0.0015$) and the impulse noise 5%. It does not show a very high cleaning performance. A data-dependent median filtering method is offered by Okano, et al. to restore picture corrupted with SPN. For the 20% of SPN corrupted picture, the filter output has an MSE of 0.0026. Such a filtering performance can be classified in good (not very good) category. For the Noise adaptive soft-switching median (NASM) filter, was developed noise detection system for soft switching to classify each pixel for pixel uncorrupted either isolated impulse noise and the noise pixel non - isolated pulsed edge or image object. Then work " no filter, the standard median filter (MED) or the weighted average of the proposed candidate for the mysterious (FWM) in the identification of distinct type them.

The scheme changes the scrolling window size, which depend on the impulse noise density. For a picture corrupted with 10% of impulse noise, the NASM filter shows a PSNR of 42 dB i.e., an MSE of6.3×10^{-5}.Its performance is very good in comparison of the fixed filters. Its filtering performance is compared with the standard filters, and the PSNR values. The input picture tree with 20% of impulse noise. It may be seen that the performance of an ROM filter is comparable to that of AID-CWM filter. So, such an adaptive decision-directed filtering scheme may not be highly appreciated. It has designed a space variant median filter for the restoration of impulse noise corrupted pictures. This is a generalized system of switching the frame average basis, which is called average (MSM) Multi- state candidate. Using three simple logic held , he came out of the MSM liquidation and switched between these adaptive CWM set of filters that have different weights center.

So, it is equivalent to the adaptive CWM filter with a space varying center weight which is dependent on the local signal statistics. At the 10% of impulse noise density, it shows a PSNR performance of 28 dB as against 22.5 dB for MED filter. In the other words, it gives an output MSE of 0.0016 even as the MED filter gives 0.0056.It has reported a Division on the basis of an intermediate type noise suppression filter in the pictures. And classified sample vectors observed in each pixel location in a mutually exclusive sections M , everyone has a filtering process. He shared control signal in the region on the basis of the difference in knowledge between the output value of the current pixel from CWM filters with variable weight center. It works satisfactorily in reducing AWGN and the mixed noise.

For the test image with the AWGN of σ^2=0.12, the filter output has output MSE of 0.0016, i.e. a PSNR of the 27.88 dB. Hence, its performance is shown to be better than that of the MED, FM, NLMS-L and the PWS filters. This filter also successfully suppresses the mixed noise and achieves a PSNR of 28.32 dB and it is claimed to be better than the MED, FM, NLMS-L and the WOS filters. A recursive LMS L-filter is proposed by for the noise removal in pictures. The coefficients derived for the non-recursive filtering are not optimal for the recursive implementation, where the estimate of current pixel depends upon the past outputs of the filters. To combat this, analogous to the design of the adaptive IIR filters, the optimization scheme is referred to as the equation error formulation is employed. The recursive filter works better in the suppressing noise than its non-recursive counter have developed the fuzzy hybrid filter (FHF) for the removal of impulse noise from highly corrupted pictures. A noise ratio in the filter window is defined and is detected. The FHF comprises of a novel detection scheme, and a fuzzy decision based on fuzzy rules. The hybrid filter also makes use of the MED filter and the MMEM filter depending on the noise ratio. The filter works for the SPN and the mixed noise conditions. So, its performance is quite good. It developed an image filter to reduce noise of a damaged image with added noise . Candidate consists of two phases. The first phase calculates the wave management for derivative 8 . The second phase uses these derivatives to perform fuzzy smoothing contributions fuzzy weight neighboring pixel values. All steps are based on fuzzy have developed a robust filtering schemes, it is totally based on hybrid fuzzy networks, for suppression of the impulse noise in pictures. This method combines position ordering of the input information and the noise correction is based on fuzzy reasoning. This hybrid scheme generally works for SPN as well as the RVIN. Russo has offered a new approach to the renovation of pictures corrupted with the AWGN. The process combines the nonlinear algorithm for details preserve the homogeneity of the noise data and automatic parameter technique based on the noise estimate for the setting. An essential feature , this method requires no knowledge of the amount of noise corruption.

1.4 The Problem Statement

In the present research work, the efforts are made to develop many efficient filtering schemes to the suppress AWGN, SPN, RVIN and the MN. The speckle noise is not considered in this work. Such a noise does not appear in the most of electronic applications and the communication systems. The present work generally focuses on the efficient suppression of AWGN, SPN, RVIN and the MN under the low noise conditions. The present-day state-of-art technology which offers very high class picture sensors, the high quality electronic circuitry, e.g., system on the chip (SOC), and the high quality channel as well. So, the noise level has drastically reduced. In last two decades, many researchers have attempted to them develop filters to suppress very high variance AWGN and the high density SPN. But the filters which are quite efficient at the high noise levels do not perform so well at the low noise levels. Hence, it is very important to design and develop highly efficient picture filters that suppress the low power noise quite effectively. Further, it is very essential to the develop efficient filters to suppress mixed noise since the practical systems are suffer from such a type of noise. For the real time applications like television, picture-cell, etc. it Is very necessary to decrease the noise power as much as likely and to retain the fine information and edges in the picture as well. Therefore, it is extremely important to have very low computational complexity so, that the filtering operation is performed in the short time for online and the real-time applications. Hence, the problem taken for this doctoral research work is "Development of Efficient Image Filters to suppress (i)SPN and the AWGN and(ii)RVIN for Online and the Real-Time Application*s".* Since linear filters do not perform well, nonlinear filtering schemes are adopted for the achieving better performance. In addition, the various adaptive filtering techniques are employed that adapt to the noise type, noise power level and the local statistics of the image. Therefore, the objective of this research work is to develop the some novel nonlinear and the adaptive digital picture filters for efficient noise suppression under the low and very low noise power conditions.

1.5 Image Metrics

It is determined by the picture quality of an objective assessment and a personal evaluation . To evaluate staff , the image must be taken into account by the human expert. The human visual system (HVS) is very complex, it is not modeled after properly. Therefore, in addition to an objective assessment , the image must be respected by the human expert to judge its quality . There are several scales used for the objective evaluation of an picture. Some of them are mean squared error (MSE) , and the mean square error (RMSE) , mean absolute error (MAE) , and noise to peak signal (NRPS) .

Let the original image is free from noise, noisy image , and the image that has filtered be represented X (m, n), R (m, n) and X (m, n) , respectively. Here, m and n provide separate spatial coordinates of the digital image . The images are the size of M pixels x N , or m = 1,2,3, ... , M, and n = 1,2,3, ... , N. Then the definition of MSE and RMSE as follows:

$$MSE = \frac{\sum_{m-1}^{M} \sum_{n-1}^{N} (\tilde{X}(m,n) - X(m,n))^2}{M \times N} \quad 1.8$$

$$RMSE = \sqrt{MSE} \quad 1.9$$

$$\text{MSE} = \frac{\sum_{m=1}^{M} \sum_{n=1}^{N} |(\tilde{X}(m,n) - X(m,n))|}{M \times N} \quad 1.10$$

PSNR is defined in a logarithmic scale, in decibels. A percentage of the peak power of the power signal to noise ratio. Since MSE power noise and the signal peak is the unit of force appears in the case of a normal signal, is defined as PSNR metric image;-

$$\text{PSNR} = 10. \log_{10}(\frac{1}{MSE}) \quad 1.11$$

Other image metric, the noise reduction factor, usually expressed in dB, is noise reduction in dB (NRDB). It is represented by:

$$\text{NRDB} = 10.\log_{10}(\frac{noise\ power\ at\ the\ input\ of\ the\ filter}{noise\ power\ at\ the\ out\ of\ the\ filter}) \quad 1.12$$

$$\Rightarrow \text{NRDB} = 10.\log_{10}(\frac{MSE_{in}}{MSE_{out}}) \quad 1.13$$

$$\Rightarrow \text{NRDB} = 10.\log_{10}\left(\frac{MSE(YX)}{MSE(\tilde{X}, X)}\right) \quad 1.14$$

Where, the MSE_{in} and MSE_{out} are the mean squared error at the input and the output of the filter. Equivalently, they are noise power at the input and the output of the filter. Therefore, the image metric, the NRDB, is a very useful parameter for the objective evaluation of a filter's performance. It is not essential to find the MSE at the output. Rather, it is very important to see how much noise power has been attenuated by the filter. This is what the parameter NRDB talks about. While these image metrics are extensively used for the evaluating quality of the restored (filtered) picture and hence the capability and the efficiency of a filtering process, none of them gives the true indication of noise in a picture. It is very essential to note that RMSE, MAE and the PSNR are all related to the MSE. Therefore, an objective evaluation with only the MSE metric is very enough. Many researchers have generally used the PSNR as the image metric. But, for the low noise conditions, the performance of many the filters will almost be the same in dB range if the PSNR is evaluated. So, only MSE is used to determine the performance of an image filter in this thesis. Further, a slight modification to the MSE is offered to fulfill with HVS. If there is a small dc offset in the restored picture, then the MSE metric gives a reasonably large error. In fact, the restored picture may not have any noise. As far as the HVS is concerned, a small dc offset doesn't contribute to any noise; rather it should be a better image, for the instance, a dark picture might have been enhanced by providing a positive dc offset. To nullify the effect of dc offset in a restored picture, the new image metric, called the mean restored mean squared error (MR-MSE), is suggested here.

Other parameter that is usually employed in the evaluating the performance of a digital image filter meant for the impulse noise suppression is percentage of spoiled pixels (PSP). It is redefined as:

$$\text{PSP} = \frac{Number\ of\ uncorrupted\ oixels\ being\ distored\ due\ to\ the\ filtering\ operation}{Total\ number\ of\ uncorrupted\ pixels\ in\ the\ filter} \qquad 1.15$$

The image metrics: MSE, PSNR, PSP and the proposed metric MR-MSE are generally used in this thesis to evaluate the performance of a digital image filter. Though, only the MSE and the MR-MSE are used in the most occasions in present research work. Of course, the significance of the PSP in evaluating an impulse noise filter is high enough and, so, it can't be ignored. But, when the filter is designed for the AWGN, this parameter can not be used.

CHAPTER-2

LITERATURE SURVEY

2.1 LITERATURE SURVEY

In this chapter we will study the varnish filter for the removal noise from RSI using the mat lab simulation. Its quantitative features and the procedure are available in literal work to create through the various filtering processes.

This article attempts to make a study of three types of noise , such as salt and pepper (SPN) , a random impulse noise and contrast (RVIN) speckles (SPKn) . He was removed from various noise between 10% to 60 % intensity using five types of filters and filter media (MF), adaptive Wiener filter (AWF) , a Gaussian filter (GF), a standard Mediterranean candidate (SMF) and adaptive filter means (AMF). The same condition applies remote sensing picture and Saturn is compared to another. And conducted a comparative study with the help of average marshalling error (MSE) and peak signal to noise ratio (PSNR) . To choose the base path to eliminate the noise of the remote sensing image. [7]

Satellite imaging is one of the most attractive sources of information to government agencies and commercial companies from lunch of commercial high-resolution satellites. This is very important especially for military applications. And satellite photos were signs of unwanted (noise) and more useful information and is due to several reasons such as bad sensors function (detectors and electronics), and the imaging environment. The Several noise removal methods should be used to eliminate or reduce the effect of the noise over the picture before information extraction. In this paper a comparative study among the four types of the noise removal filters is carried out. The Investigated filters are the Median Filter, Wiener Filter, Average Filter and the Bilateral Filter. These filters are applied on a test set of the four high resolution remote sensing pictures acquired by the different satellites (GeoEye.1, I kenos', and World View2). The test pictures are contaminated by the four types of noise: Salt and pepper noise (SPN) , and noise Shooting (Poisson noise), noise and noise speckles Blur. It is compared to the results of the implementation of the four candidates and evaluated and analyzed. And it is evaluated using average marshalling error (MSE), the peak signal to noise ratio (PSNR) , and measuring the index of structural similarity (South Sudan Independence Movement) , contradiction (D) and a quality index of the universal picture (UIQI) . [8]

The noise can be introduced into picture during the image acquisition and the transmission process. Due to the noise some pixels values could not reflect the true intensities of the real scene. This means that the noises cause the degradation of picture quality, so a noise reduction processes should be conducted before the image analysis. The most commonly occurring types of the noise are i)The Impulse noise, ii) Additive noise (e.g. Gaussian noise) and iii) The Multiplicative noise (e.g. Speckle noise) [1]. The Several noise removal methods are published in the literatures. They can be the classified into spatial (image) domain methods and the frequency domain methods. The performance of the noise removal methods are changes according to the noise type. A noise removal method should perform well with the specific noise type while not capable with the other noise type. The study presented in this paper will illustrate this after applying the investigated filters on different types of the noise.[9]

Digital image dispensation is the most popular method used in remote sensing. He helped to access technical data in digital and multi- wavelength, and IT services in terms of speed of data and large storage capacities to respond. It could be that most studies are also taking advantage of this artistic diversity of digital image dispensation , and location of copies and keep the accuracy of the original data. Noise is removable using an iterative filtering means in space , which requires that Much less time processing the removal of the Fourier frequency shift field. Median weight filter (WMF) is based on the decomposition removes the impulse noise threshold with detail in the image dispensation of an excellent candidate capacity , compared to non - linear and linear filter . Intermediate standard filter (SMF) is nonlinear, the filtering method low pass to be used for removal And " spots " image noise . Candidate means can lead to rhythm, the low-pass filters , this kind of noisy image can potentially eliminate the noise without affecting "clean" pixel. intermediate filters remove isolated pixels , either light or dark . Designed Mediterranean candidate adaptive (MFA) to eliminate problems that confronted the liquidation of S mediator. adaptive filtering (AF) change their behavior based on statistical properties of the image in the filter. The performance of the adaptive filter is usually better than their non - adaptive . Improved performance in the cost Filter added complexity. Moderation , Contrast , both with important statistical measures filter adaptable and can be designed . There are many ways to reduce noise. The use of traditional Mediterranean and the candidate of liquidation generally means to reduce noise , salt and pepper and Gaussian noise respectively . At two in the image and presence of the sound at the same time , the use of a method that a single candidate can not be achieved due to the design. [10]

In this work, we have various filters to apply remote sensing images of rumor for them. primary key challenge is to reduce noise to reduce or eliminate the noise without missing other aspects of the image. And RS (Remote Sensing) image the rumor involving the manipulation of the image data to produce a visual image of high quality . There are different types of noise that affect remote sensing Photos , but we must determine the noise of rushing noise while Gaussian noise , salt and pepper. Usually we take the simulation of remote sensing images and analyzed with the average candidate , the average candidate, heavily candidate of the United Nations and the liquidation of Weiner and the use of statistical quality standards. Analysis of the impact of the art noise suppression described in this paragraph . [11]

The Noise reduction in satellite imagery Researcher, challenges the digital image dispensation. There are various ways to reduce the noise. Overall, I found that the noise spots are usually taken into the account and the related methods in synthetic aperture radar image and satellite images, the medical images, etc. to detect and reduce their development suggestions. The importance of community is to create a direct link to the fields of picture analysis. This will help the people to better understand the context in which the image analysis and the remote sensing appear. The Digital image dispensation is the very important use of remote sensing technology. It helps in large data storage and in the dispensation capabilities speed access to the digital technology and the multi-wave length, and in computer data services .This is because many studies also take benefit from this diversity and a copy of the position of the artistic digital image dispensation and preserves the accuracy of the original information. The Sensors used on the target or area or phenomenon by analyzing some of the remote access information is subjected to information obtained by the remote sensing. These objects do not touch the check. The Images obtained by satellite in the many applications, such as the environmental resource tracking land, the geographical mapping , crop forecasting , urban growth and weather , the flood and fire control, and other useful.[12]

Get before being processed for the further analysis which represents a major challenge for the researcher; remove noise from the picture, an effective method. The Noise can be reduced when capturing pictures or image transmission. Before applying the image processing, the image tools is on the highest priority, the release of the image noise. The Adequate algorithms are available, but they have their own assumptions, the advantages and the disadvantages. This type of noise removal algorithms is to remove the noise present in the image depending on this type of noise. This is the order to get the best results if test the picture and follow the assumptions of the model, and fails otherwise. In this article, remove noise did spotlight some important types of the noise and the comparative analysis techniques. This presents the results and findings of application of the different types of the image noise model using a variety of the noise reduction techniques.[13]

To send a digital image of the vision is modern data communications network is the major problem. This is sent from the sender side images may not be the same as the receiving end. After the transfer of the picture obtained is often damaged noise, It is because of the noise has been provided in transmission medium channel noise in the measurement process and the digital data stored in the quantization error during. The picture in need of the treatment, they should be used for more applications before the end of the reception. To restore the original picture for researcher a daunting task at the end of the reception. The noise can be reduced when capturing images or the image transmission. Before applying the image processing, picture tools to the highest priority, release of the image noise. This article which discusses the different sounds, such as the salt and pepper, Poisson noise filtration and the various techniques can be used to reduce the noise in the picture.[14]

Noise, any unwanted information pollution picture, Appearing in the picture interference from the different sources. The method to obtaining the digital images, wherein the optical picture into an electrical signal, and then successively taken samples, noise appears in the basic process of the digital picture. Near are various ways to make the noise display images, depending on the picture is shaped. The Satellite imagery, that contains the noise signal, and the 1ead picture distortion and cannot be properly understand and learn, need to adopt the appropriate filters to the limit or decrease a lot of the noise. It also helps in the option of the better interpretation of the image content. The picture noise is random brightness or contrast of the picture color information (not in the presence of an object photography), and is basically part of the electronic noise. The Image processing electronics is a sector where a small unit called pixels, then a different process is implemented. The Noise should usually be derived from the sensor or a canal through the transmission image acquisition and the digital signal transmission. In the field of the digital image processing, and improve the picture noise removal is a key issue. The Gaussian (white noise), the salt and pepper and the speckle noise also started with the help of the some effective techniques to restore them down which is a major concern. When added the picture noise destruction of its parts. In order to maintain the real picture, the noise should be removed from it. For the purpose of the strengthening should improve the picture contrast. The Image filtering these days became active in the field of image processing research, despite a lot of research in the many different fields. The world is undergoing what is necessary to exchange the information to throughout the world, the world in the fraction of a second as the Internet. While these may include the text, images or videos, the damage has been spread through the media of the communication due to the added noise. When in camera color blue color than it uses the multiple channels to enlarge the green or red channel.[15]

CHAPTER 3

BASIC CONCEPT OF DE- NOISE TECHNIQUES

3.1 Image Noise

Noise is defined as the People of random deviation from the picture brightness, contrast and color sequence in the image. In addition, it refers to electronic noise. It is never present in the real image of the object. Rather, the presentation by the sensor circuit from a scanner or a digital camera. The image noise is the result of a captured sterile image that adds information is useless for the image. It may even exist in the film grain. The actual meaning of noise in digital circuits dates back to the ancient definitions. These definitions simply classified noise as an unwanted signal. Later on noise was categorically termed as unsolicited electrical fluctuations. The magnitude of image noise varies randomly that depends on the availability of intensity of light in the surroundings. Generally noise is nominal in images captured by a digital camera in good light. But noise level shoots up enormously in astronomical images taken during pitch dark nights. Thus various de – noising techniques are extremely vital. We have discussed some of the noise filtering techniques with their respective filter algorithms and codes in this thesis for a specific type of noise.

3.2 Noise Types

Image noise is classified under four major categories. These are –

- Gaussian Noise (Amplifier Noise)
- Salt – and – Pepper Noise
- Shot Noise (Poisson Noise)
- Speckle Noise

3.2.1 Gaussian Noise (Amplifier Noise)

Gaussian noise and its filtering techniques are the areas of study of this thesis. It is even renowned as amplifier noise because it is abundantly found in digital cameras where amplification is required on a larger scale. It is more evident in that color channel in which large scale amplification is implemented. For instance it will occur more in blue color channel in comparison to red and green channels for cases where blue channel is predominantly amplified. Basically, there is a probability density function of statistical noise is equivalent to the normal distribution. It is a normal distribution also known as Gaussian name . Therefore , and so-called Gaussian noise . white Gaussian noise is a particular case of the same identical image and independent values . He got that kind of critical applications.

3.2.2 Salt and Pepper

Pepper noise is composed of dark pixels in the light areas and bright pixels in dark areas - the picture made of salt - and . The main reasons for this type of noise can be - analog to digital errors, transmission errors , a few dead pixels and so on . This can be reduced to a large extent using subtracting the dark image or distortion between pixels.

3.2.3 Shot Noise (Poisson Noise)

I find this kind of noise where the energy -containing molecules are less numerous than the optimal target level. This leads to statistical fluctuations which can be detected during the measurement of the image. These particles may be considered electronic circuits and electronic photons in the case of an optical device.

3.2.4 Speckle Noise

Noise spots is the noise present in the granules . He specifically degrades the quality of radar and synthetic aperture radar (SAR) images. Blot the face of noise in the results of conventional radars. This is due to random fluctuations , particularly in the return signal of the current size of an object of one picture element. Speckle noise in SAR makes the perception of image difficult to gauge by enhancing the mean grey level of a local area. It mainly exists due to continuous processing of back scattered signals from different types of targets. SAR oceanography is a good example of the same. It occurs from signals through elementary scatters, gravity – capillary ripples beneath the image of the sea waves.

3.3 Filter Types

This thesis mainly deals with various filtering techniques of the Gaussian noise. This type of noise was introduced when the GPP was integrated with the FPGA based processor. This was done for an improved quality of processed image. The experiment was a success to an extent as described earlier but it led to the generation of Gaussian noise in a noticeable quantity. Hence we came up with certain filters and devised their codes to eliminate the prevalent Gaussian image noise. The general algorithms used for the subsequent coding purposes have also been illustrated in the following chapter. Appendix C comprises of codes for each type of filter implemented in this thesis. The simulation results have also been attached in the next chapter.

Various filters utilized to eliminate Gaussian image noise in this thesis are –

- Adaptive Weiner Filter
- Adaptive Average Filter
- Adaptive Median Filter
- Relaxed Median Filter

3.3.1 Adaptive Weiner Filter

Adaptive Weiner filter is a popular method that is employed for enhancement of image quality and noise removal. Weiner filter concentrates on getting a clean image out of an image corrupted by additive noise. It is mainly And the statistical approach . These filters are usually working for the desired frequency response . He approaches the appointment by a couple of different angles. Presumably one of them to have knowledge of the spectral characteristics of the original image and noise, while the other seeks to LTI rate, very close to the original image. Even in this thesis too it gives a clearer version of an image mixed with Gaussian noise. Weiner filters are characterized by following points –

a) Hypothesis : Image and additive stochastic noise linear processes compatible with the known spectral characteristics .
b) Requirement: The filter must be physically possible. In other words it must be causal.
c) Performance Standards : Minimum mean - square error

Mathematically designed optimal filter by minimizing the average error yard (MSE) between (n) of the desired signal and the signal is estimated picture " (n.) One of the main shortcomings of Weiner candidate is that the frequency response of stagnant frequencies for all. He even must calculate the own signal spectral density and noise before the appointment of the image sequence . This estimation is cumbersome too and consumes time as well. Our work comprises of Weiner filter codes to eliminate Gaussian noise in cases of the images of a house and a tree. These codes have been written down for two distinct values of standard deviation for both the images.[17]

3.3.2 Adaptive Average Filter

Fixed Average filters need prior information of the noise and the original image signal. Then only they are efficient in noise elimination. On the contrary the adaptive window type filters do not need any such information. They have the inherent ability to adjust the impulse response that filters out correlated signal in the input. They require little or even no knowledge of neither the image signal nor the noise. Prior information is not at all needed irrespective of the fact that whether the signal is a narrowband or a broadband. Even a vice – versa situation is handled as well by simple adjustment of window size through sliding mechanism. The lack of prior knowledge at times may lead to hampering of the signal while subtracting the noise out of it. Thus the adaptive filter faces the scenario by adjusting the impulse response to minimize the error signal considering the filter output. Filter weights and impulse responses are taken care by various adaptive algorithms. Thus adaptive filters reduce noise with least signal distortion. All in all adaptive filtering reduces noise levels to a great extent in comparison to direct filtering methods.

The value of mean square error depends on the application used. Two major conditions that are used are least mean square error and minimization of temporal average of the least square error and so on. The most popular algorithms for this type of filter are – Least Mean Square (LMS) algorithm, Recursive Least Squares (RLS) algorithm. Mean square error condition cooperates to understand the mean square error criterion. This thesis contains adaptive window filter of two sizes – 3x3 and 5x5. Codes have been written for both sizes of windows for images of a tree and a female named Lena here. Appendix C contains the codes with the next chapter comprising of the simulation results.[18]

3.3.3 Adaptive Median Filter

Median filter is generally applied in cases of colored images. It can treat both color distortion and loss of characteristics of edge preservation. It achieves this by considering all the three color components at the same time. Several types of median filter are –

a) Scalar Median Filter – Median filter modified on the basis of color and proposed by Valavanis et al is regarded as scalar median filter. In order to restrict the color based distortions to minimal this filter follows certain rules. It initially reduces the hue changes to as less as possible. Then the change in the value of saturation is also kept under strict surveillance. As it is believed that increment of saturation is way better than its subsequent decrement. Finally the contrast of the luminance is fixed to its highest value.

b) Vector Median Filter – Scalar median filter at times does not produces values for pixels that do not exist in the original image. Vector median filter is a good tool to overcome this problem. Now in vector median filter entire calculation depends on the filter weights. Thus the weightings may generate error if not calculated precisely. This in turn may lead to the loss of edge preservation characteristics. However unlike scalar median filter it is guaranteed that this mode of filtering is completely free of additional ambiguous color vectors.

c) Reduced Vector Median Filter – Now once the vector median filter gained popularity, it was observed that its computation was pretty tedious and time consuming. Thus Regazzoni and Teschioni came up with an approximate version of the same. They named it as reduced median filter. They found major usage in scanners and in space filling curves. In scanners they performed the function of converting the three dimensional color vectors into a single dimensional space vector. Thereafter the median is estimated by the age old conventional technique. However in reduced median filter the signal to noise ratio was determined to be worse than that of their counterpart.

d) Median Filter Applied to Chromaticity in the HSI space – Thesis an extremely unique technique which came up because of the confusion in the order of rank between color vectors in the median filtering technique. A scientist named Frey suggested that the ordering is more reliable when it is done on the basis of hue and chromaticity. Earlier the mean value of the color vectors was considered for ordering purposes. In this technique even the color vector was considered in the HSI space. Thus this model gets very close to a kind of median filter. Here the mean value is searched for in the chromaticity plane and it is ensured that the value is unaltered in the output image. Thus this method works exclusively on the chromaticity.

e) Median Filter Based on Conditional Ordering in the HSV space – Here conditional ordering is followed. Vectors are first ordered as per the value of the first component and the next components follow suit. This ordering technique was suggested by Vardavoulia. First of all vectors are sorted based on the HSV color space depending from smallest to the greatest value. Then the saturation value s is arranged in the descending order from the greatest to the smallest. Then values of s and v are compared. Finally these values are arranged in ascending order for pixel sorting.

f) Vector Directional Filters – These are multivariate filters that depend on the angle between the color image vectors for ordering purposes. They follow vector ordering principles based on the polar coordinates. Thus the vector directional filters are similar in their approach as they also follow the chromaticity components of the color. They operate mainly direction of image vectors and keep eliminating the vectors comprising of atypical direction. Consequently they are only employed for specific purposes where the estimation of précised direction is of utmost necessity.

3.3.4 Relaxed Median Filter

Relaxed median Supposed to be a candidate for a modified version of median filter. It is similar in characteristics but easier to implement. The relaxed median filter works on the principle of lower and upper bounds respectively. These bounds define a window that contains all the gray levels. These gray levels are not filtered. Thus in case the input belongs to the sub – list, it remains unfiltered. If the input is outside the sub – list, the standard value of relax median filter is taken as the final result. Thus relaxed median filter is comparatively faster than the standard median filter. Since it is a sub class of the median filter, the ranking order follows exactly the same principle as that of the median filter. Below mentioned figure depicts an original image. Then noise is added to the figure and finally filtered image is shown obtained via relaxed median filter.

Figure 3.1 – Original Image of Lena.

Figure 3.2 – Image Corrupted By Gaussian Noise.

Figure 3.3 – Image Filtered By Standard Median Filter.

Figure 3.4 – Image Filtered By Relaxed Median Filter.

Thus the above mentioned image of Lena has been used in our coding also. All these four figures depict a comparative study of the filtering capabilities of the standard and the relaxed median filter. This makes the capability of each and every type of median filter crystal clear. In this way this chapter details all types of image noises with special emphasis on Gaussian noise. Later on it gives the theoretical description of all the filtering techniques undertaken in this thesis to eliminate Gaussian noise completely from the original image. The introduction of the tool used, algorithms followed and the simulation results generated are dealt with in the next chapter.

CHAPTER 4
SIMULATION AND ANALYSIS

4.1 Tool Introduction

The tool used for the simulation of codes in this thesis is MATLAB. MATLAB simulation of codes led to the generation of results. The screen shot of those results is included in the second half of this chapter. The name MATLAB is abbreviated as Matrix Laboratory. MATLAB was designed to gain access to the matrix based software used for LINPACK and EISPACK based projects. Linpack is a set of linear system is the package and the EISPACK Aegean system . In other words MATLAB is the language used in the technical accounts at a high rate of return. It provides calculation and visualization and programming environment under one roof . It meets the requirements of the modern world . They consist of complex data structures , it contains built - in editing capability , and supports debugging tools and creates an object-oriented programming environment . These features make MATLAB ideal for the purposes of research and teaching as well .

MATLAB is way above all other computer languages like – C, FORTAN and so on. Its efficiency is way ahead in solving technical problems. MATLAB behaves like an interactive system that makes the user feel at ease with the system. Appearance the database that does not require a table dimension . It came into being in the year 1984. Slowly but surely it kept gaining popularity. Today it is considered as perhaps the best technical computing tool by numerous industries and universities worldwide. Primary features of MATLAB include built – in routines, easy to use graphics commands and toolbox. Built – in routines enable broad range of sophisticated calculations. Graphics commands make immediate result visualization a sure shot possibility. Toolbox is made up of packages containing special applications. Some of them are – Signal processing , symbolic computation , control theory , simulation , optimization, and many other uses in the fields of applied science and engineering . MATLAB is run on a wide range of platforms like – UNIX, WINDOWS, Mac, CAEN and so on. It is started by double clicking the MATLAB icon or via typing matlab in the UNIX command line. The version number is imprinted on the top of the starting window. Some specific applications desire MATLAB version 5.0 or later ones. On CAEN platform we need to select 5.0 or higher version via the select command. In general, the latest version is set as the default version. Even an amateur can get started with MATLAB by taking directions from the MATLAB help. Thus all in all it is a high performance, user friendly, popular and effective tool. Consequently, we chose this tool for the code simulation of our thesis. Our codes were simulated successfully and results were generated instantaneously.

4.2 Algorithm Profile

This section makes note of the tracking algorithm for rules of construction to eliminate the effects of noise from the image signal. It highlights general staff algorithm for each type of spread in this thesis filter to remove Gaussian noise.

4.2.1 Adaptive Weiner Filter

Wiener filters to adapt to stick in the LMS algorithm of the public to generate the code . They are based on the principle of the error is calculated by the filter coefficients. It is calculated output of the FIR filter equation –

$$y(n) = Z^{N-1}\, m = 0 \qquad w(n)x(n-m)$$

Here n stands for the number of iterations. An error signal in the equation below – Account

$$e(n) = d(n) - y(n)$$

The above mentioned equations update the filter weight via the error signal and the input signal. The equation for the weights comes out as –

$$w(n+1) = w(n) + ue(n)x(n)$$

Taking the above terms in account, w(n) is the weight of the signal, w(n+1) is the weight of the next input signal, e(n) is the error vector in the input signal and x(n) is the original input signal. In this way the first equation determines the algorithmic output of the FIR filter. The error and weight related terms of the first equation are ascertained via the second and the third equations respectively. This figure is sporting the algorithm followed by filters to fit Weiner. The following is a table of the same.

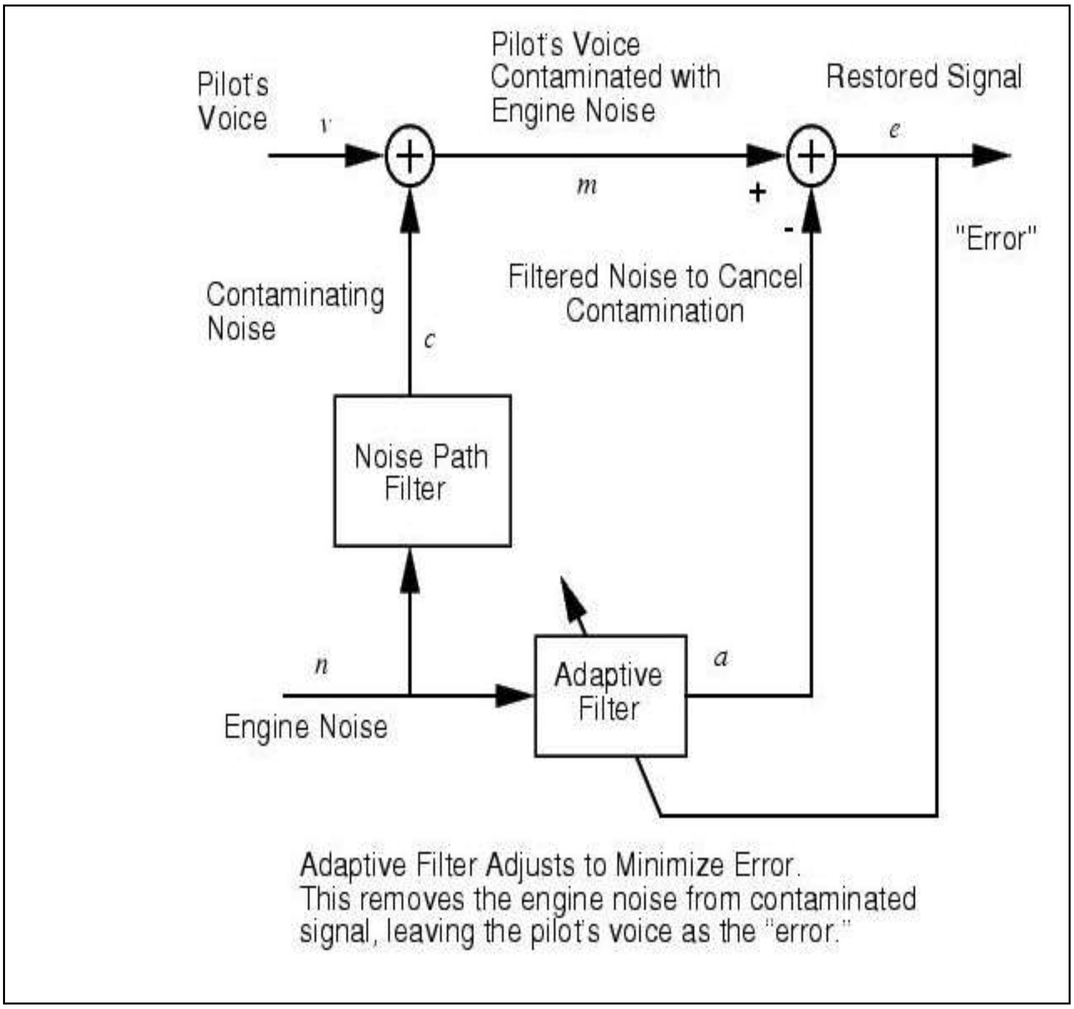

Figure 4.1 – Block diagram Representing the algorithm of the Adaptive Filter Weiner .

This diagram further clarifies the above mentioned mathematical derivation of the Adaptive Weiner Filter. This LMS algorithm is abbreviated as Least Mean Square algorithm. It derives its name from the fact that it takes least value from all the squared values of the mean to account for the final output. This explains LMS algorithm.

4.2.2 Adaptive Window Filter

In this thesis , the symbols had written two types of candidate window to adjust. It has a size with 3x3 window while the other having the size of the 5X5 window. He was writing codes in the different values of the standard deviation for each of these filters. The output is the image that has leaked from a tree and a house. However, this section deals with the profile algorithm respected when writing these symbols. The algorithm described below are the same size for all windows. An image size of value should not be changed.

Let X (i, j) the pixel being processed . CNN socket as my size of the sliding window , which is used in the filter. The size also (2L + 1) Q (2L + 1). The focus in the X (i, j) and the elements of this window are as CNN, j = { Xi St., J , T, -L < u, v < L} . L represents here the size of the window. Only the value of L change to change the frame size. See algorithm steps below -

Allow the X the original image with noise. It takes the standard deviation of noise in two distinct values. It is through the use of a quick way to Immerkaer . X (i, j) as the central pixels . Filter D taken from the window size of 3X3 picture noisy - A 2. Then you put each item with the central pixel. The absolute value of the difference that AD = [C, D - X (i, j)] . The pixels are stored as the one-dimensional array is called DA (x). This is done so that the absolute difference m < (SF * SD). Here is a factor SF homogeneity and SD is the standard deviation . In the case of a number of elements in the AD (Q) is the minimum (2 * W) - 1, then the DA means (x) is taken into account and the value of the center, which is replaced by . It has been unspecified higher than for X (i , j). W here is taken three to five 3X3 framework of the 5X5 window. If the case has not increased the size of the window, then the process is repeated over and over again. and repeated third and sixth stages again and again, even if the overall picture has not made clear.

These are the steps which are followed by us for the coding purpose of adaptive window filter. These algorithm forms the backbone of functioning of the window filter. The concept of size of window was given special focus during the coding of the window filters. However by comparing the results of the 3x3 window with that of the 5x5 window the idea of varying the size of window is made clearer. The findings also shed light on the output variable sliding window size by eliminating image noise . the window size is increased only in cases where it does not meet the requirement of the fifth algorithm. Each time the process begins with the size less than default window. Therefore , it verifies

condition mentioned in the fifth condition of the statement. On meeting the conditions the task ends there only. Therefore on failing that condition Sliding window begins to grow until the case is satisfied. This explains in detail followed by the coding window filter algorithm in this thesis.

4.2.3 Adaptive Median Filter

Mediterranean candidate based on the statistical characteristics of the image, which is better for the liquidation of the image. As mentioned in the previous chapter , it only works by replacing the median pixel neighborhood grayscale. It is represented by - And (x, y) = { g

Mean (s, t) } Here f (x , y) the gray value pixel neighboring screens on a collective basis . it is derived out of mean calculation of almost all the neighboring pixels alternately. The median is calculated from the real value of the pixel only. Hence median filters perform precise, fast and accurate elimination of the noise. It makes them pretty popular as they do it without any blurring for all types of the noises. They even transform the picture to an extensively smooth piece. The codes which are used in this thesis for the filtering purpose of the median filters follow a certain algorithm. On the next page of this chapter describes the steps of the algorithms put to use.

4.2.4 Relaxed Median Filter

The Relaxed median filter follows are exactly as the same set of algorithmic rules as in the case of the median filter. The only exception being the fact which gives it the name of the relaxed median filter is that its value of P_{Min} to P_{Max} lies in the more relaxed range. The value of window vector may vary from 0 to 300. In the median filter this is restricted to 255 only. This thesis work involves the coding of relaxed median filter as well. The codes were written on the basis of the same algorithm as in the case of the median filter.

4.3 Simulation Results

This is the most significant sections of our thesis. This includes the screen shot of the results generated after the design of codes for various types of the filters. The codes were run on MATLAB and the simulation results were snapped to attach in this part of the fourth chapter.

4.3.1 Simulation of Gaussian noise removed for varnish filter

TABLE: 4.1 Comparison of PSNR and MSE in Gaussian Noise by filter in 1%

FILTER	PSNR VALUE	MSE VALUE
Average	31.422	47.2330
Winner	32.286	37.8279
Median	31.852	42.7754

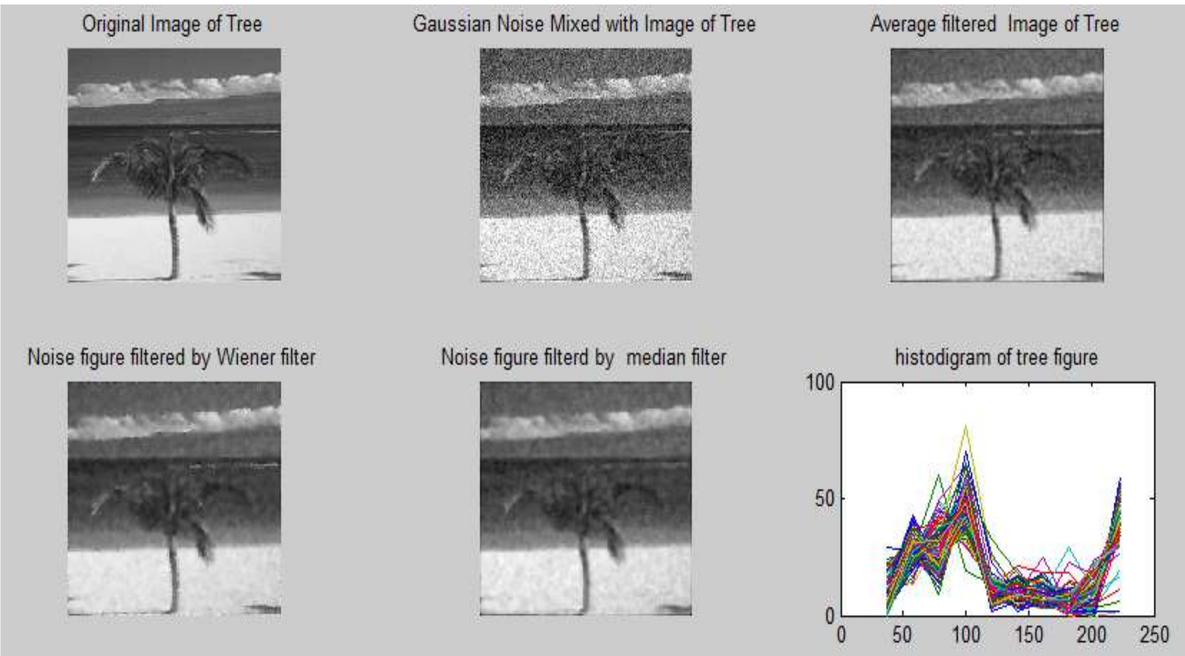

Fig 4.1 Noise mixed in 1%

TABLE: 4.2 Comparison of PSNR and MSE in Gaussian Noise by filter in 2%

FILTER	PSNR VALUE	MSE VALUE
Average	30.157	63.200
Winner	31.053	51.470
Median	30.777	54.797

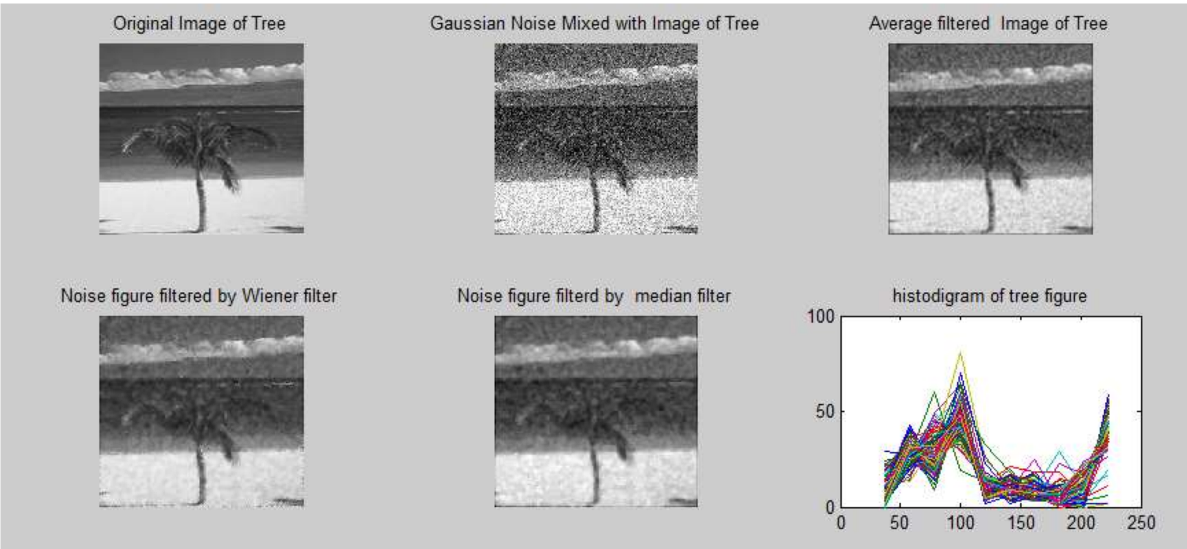

Fig 4.2 Noise mixed in 2%

TABLE: 4.3 Comparison of PSNR and MSE in Gaussian Noise by filter in 5%

FILTER	PSNR VALUE	MSE VALUE
Average	28.794	86.513
Winner	29.162	79.481
Median	29.523	73.128

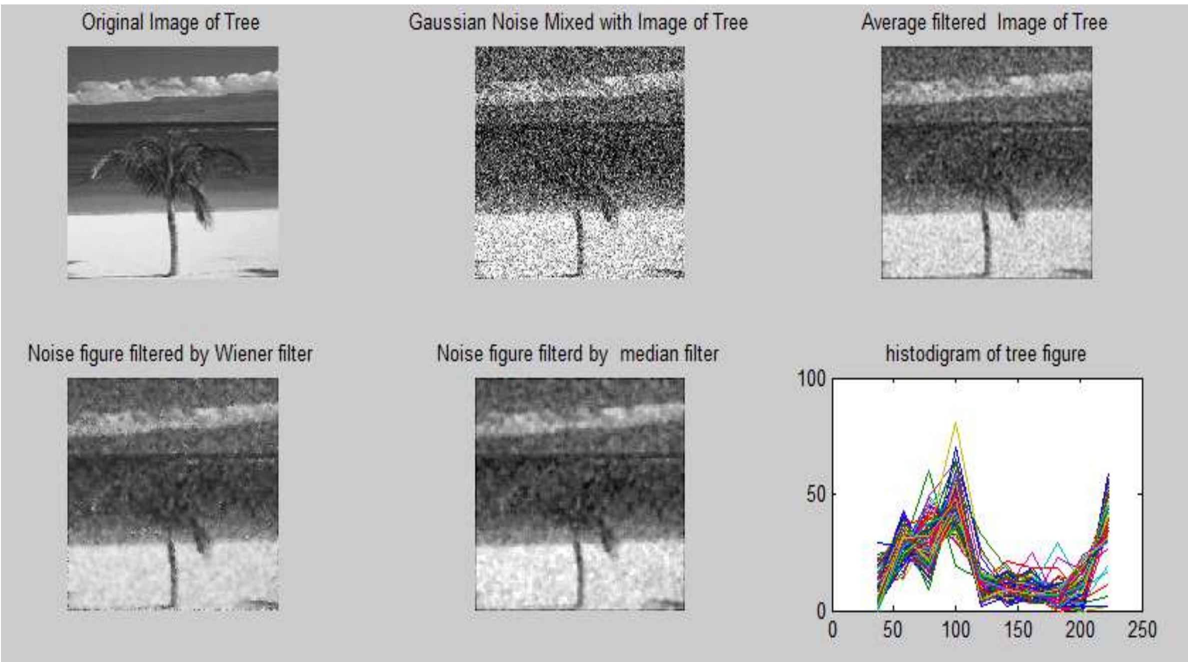

Fig 4.3Gaussian Noise by filter in 5%

4.3.2 Simulation of Salt and Pepper removed for varnish filter

TABLE: 4.4 Comparison of PSNR and MSE in Salt and Pepper Noise by filter in 1%

FILTER	PSNR VALUE	MSE VALUE
Average	30.008	65.401
Winner	31.100	50.869
Median	33.983	26.189

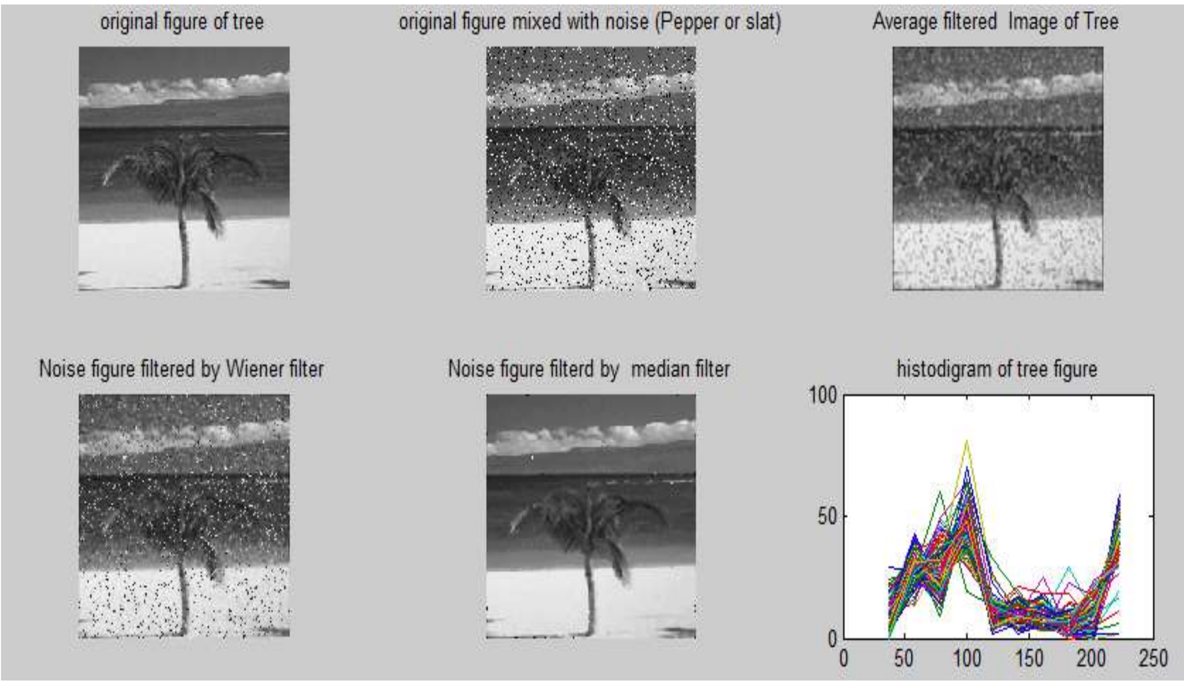

Fig 4.4 Noise mixed in 1%

TABLE: 4.5 Comparison of PSNR and MSE in Salt and Pepper Noise by filter in 5%

FILTER	PSNR VALUE	MSE VALUE
Average	31.513	46.251
Winner	33.254	30.979
Median	35.178	19.887

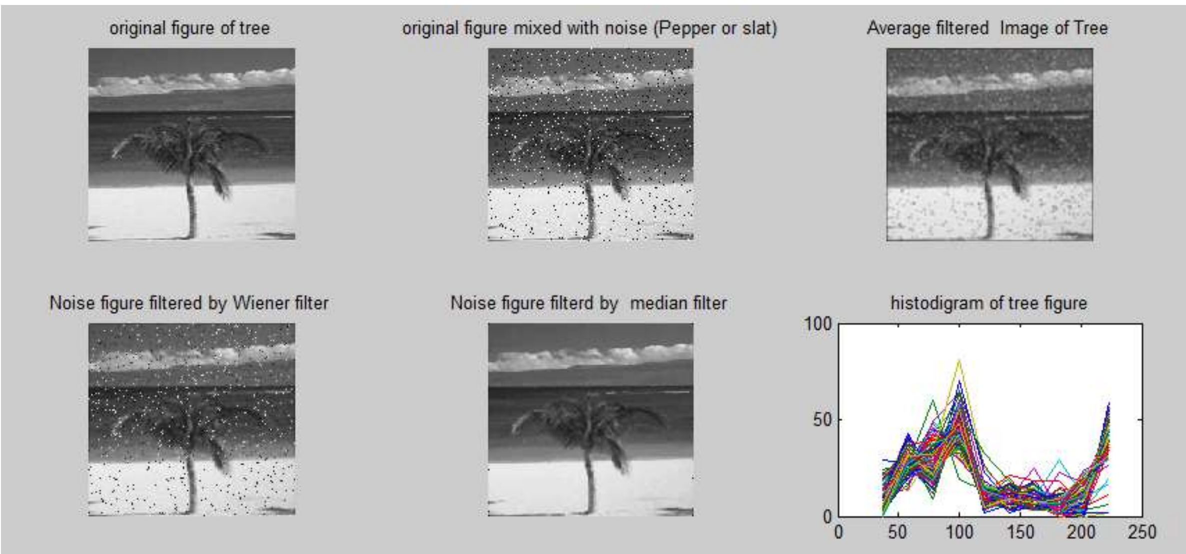

Fig 4.5 Noise mixed in 5%

4.3.3Simulation of spackle removed for varnish filter

TABLE: 4.6 Comparison of PSNR and MSE in spackle Noise by filter in 3%

FILTER	PSNR VALUE	MSE VALUE
Average	28.672	88.959
Winner	29.199	78.792
Median	29.223	78.213

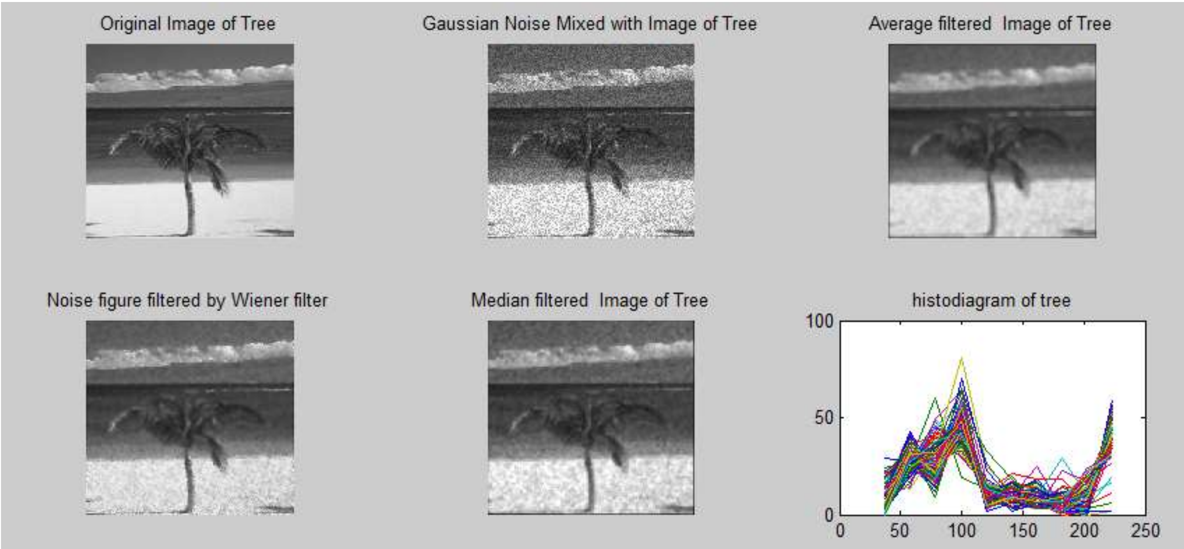

Fig 4.6 Noise mixed in 3%

TABLE: 4.7 Comparison of PSNR and MSE in spackle Noise by filter in 3%

FILTER	PSNR VALUE	MSE VALUE
Average	28.279	97.394
Winner	28.646	89.505
Median	28.881	84.781

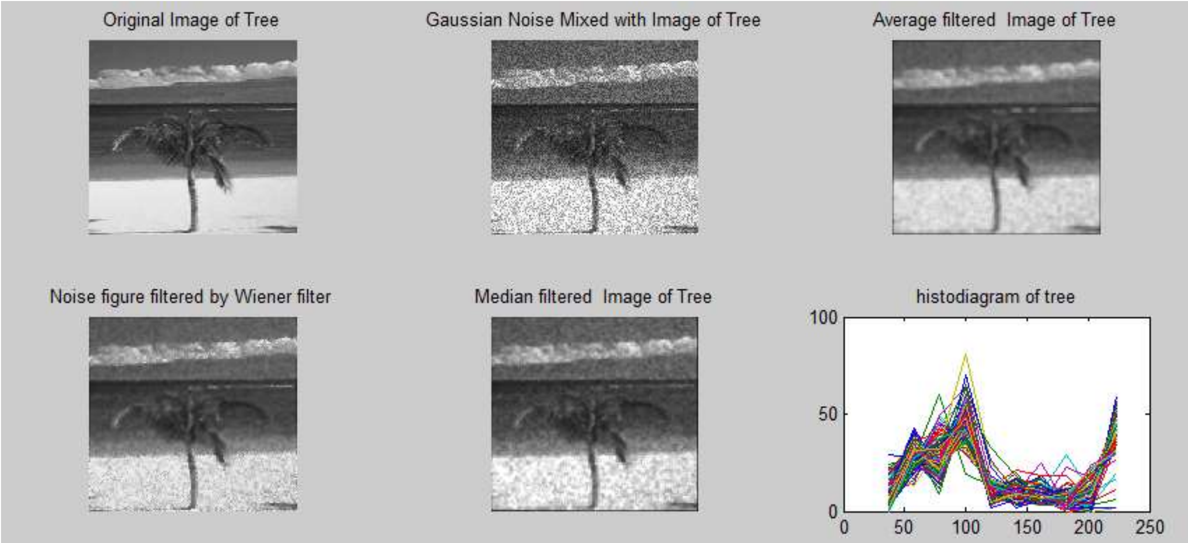

Fig 4.7 Noise mixed in 5%

4.3.4Simulation of Poisson removed for varnish filter

TABLE: 4.8 Comparison of PSNR and MSE in Poisson Noise by filter

FILTER	PSNR VALUE	MSE VALUE
Average	33.845	27.036
Winner	34.901	21.199
Median	33.915	26.504

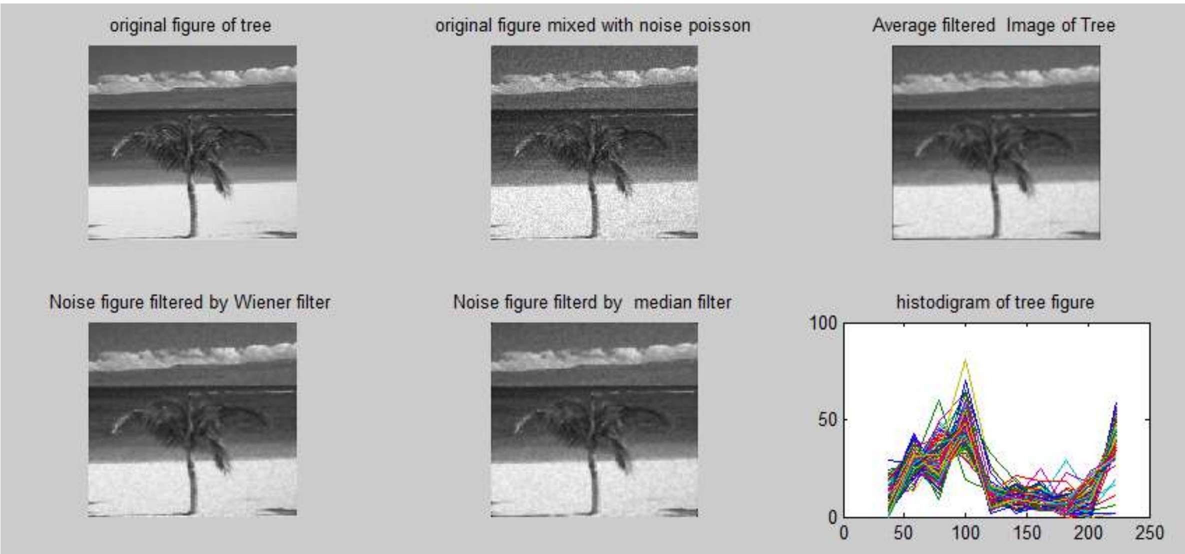

Fig 4.8 Noise mixed in poison

CHAPTER-5
CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

In this thesis, various types of the noise in a digital image and their sources, the practical noise levels, and the range of the noise power in a practical picture are studied. Then, the types of noise and the noise levels are studied for the communication applications like television and the photo-phones. For the real-time applications, effort has been made to develop the efficient nonlinear filters to suppress the AWGN, SPN, Poisson, Spackle RVIN and the MN. Image signal is transmitted in the analog form; the noise should be a mixed version of AWGN and the SPN. On the other hand, if the image signal is transmitted in the digital form, then the received signal is corrupted with the RVIN. So, many efficient filters are proposed to suppress MN and the RVIN quite effectively without blurring the edges and without distorting the fine-details of the picture. The proposed filtering schemes are meant for the real-time applications.

Various approaches adopted to achieve these goals are:

a) We have implemented the above mentioned filter in Matlab to recover the picture degraded by Gaussian noise and the Poisson noise Slat & pepper, Speckle.

b) The Median filters provide better results in case of Gaussian noise, Poisson noise slat & Pepper. The result is show in PSNR and the MSE comparison parameters table.

c) Three novel impulse detection schemes are to detect the impulse noise quite effectively.

5.2 FUTURE SCOPE

The study can be extended in the future in following possible directions:

a) In the literature of the image processing, several techniques are implemented in transform domain are available. Performance of the spatial techniques can be compared with the transform domain methods and possibility of designing a new algorithm which exploits features of both the techniques can be explored.

b) Neuron-fuzzy techniques have been successfully applied for the many image processing applications. Investigations can be carried out for the assessing the performance of the existing techniques and developing a new algorithm for filtering of the random valued impulse noise in monochrome as well as color images.