CHAPTER 3

DE-NOISING TECHNIQUES

3.1 INTRODUCTION

Noise is an unwanted signal that interferes with the original signal and degrades the visual quality of digital image. The main sources of noise in the digital image are imperfect instruments, image acquisition process, transmission and compression, environmental conditions during image acquisition, insufficient light levels and sensor temperature, which affect the imaging sensor. Further noise will be introduced in the image when dust particles are present on the scanner screen. The image will be corrupt when there is interference of noise in the transmission channel. In the modern age, visual information is transmitted in the form of digital images by way of communication. But the image secured after transmission is often corrupted. Before it can be used in application, the received image requires processing to produce a visually high quality image.

Digital image processing introduces Image de-noising techniques which creates the pre-processing step to eliminate noise from the original image. It is a method of removing degradation of image that has occurred at the time of image capturing due to the electronic and photometric sources. Degradation comes from blurring as well as noise. Identification of de-noising algorithm is application dependent. Therefore it is better to know about the type of noise present in the image to enable selection of the required de-noising algorithm.
Still image de-noising poses a challenging problem for researchers as image de-noising causes blurring and introduces artifacts. Different types of image poses various types of noise. Different noise models are made use of to present different noise types. Hence de-noising method depends on the problem specific and relies on the type of image and noise model.

Digital images find an important role in research and technology like geographical information systems and in the field of medical science such as ultrasound imaging, X-ray imaging, computer tomography and MRI as well. Blurring is the type of bandwidth reduction of images due to imperfect image formation process such as relative motion between camera and original scene or by an optical system that is out of focus.

3.1.1 Noise Models

Noise is unwanted information in digital images. Noise produces undesirable effects such as artifacts, unrealistic edges, unseen lines, corners, blurred objects and disturbs background scenes. To reduce these undesirable effects, prior learning of noise models is essential for further processing. Digital noise may arise from various kinds of sources such as Charge Coupled Device (CCD) and Complementary Metal Oxide Semiconductor (CMOS) sensors. In some sense, points spreading function (PSF) and modulation transfer function (MTF) have been used for timely, complete and quantitative analysis of noise models. Probability density function (PDF) or Histogram is also used to design and characterize the noise models. Here few noise models, their types and categories in digital images are discussed.

Gaussian Noise Model: It is also called as electronic noise because it arises in amplifiers or detectors. Gaussian noise caused by natural sources such as thermal vibration of atoms and discrete nature of radiation of
warm objects. Gaussian noise generally disturbs the gray values in digital images. That is why Gaussian noise model essentially designed and characteristics by its PDF or normalizes histogram with respect to gray value.

Speckle Noise: This noise is multiplicative noise. Their appearance is seen in coherent imaging system such as laser, radar and acoustics etc.. Speckle noise can exist similar in an image as Gaussian noise.

Random noise : Random noise caused by interferences among electronic components. If this noise is stationary, it has fixed amplitude, frequency and phase. Noise presents in communication channel is low rank noise. In a signal processing, it is more advantagable (more realistic) to considering noise model in a lower dimensionality space.

Salt and Pepper Noise: This is also called data drop noise because statistically its drop the original data values. This noise is also referred as salt and pepper noise. However the image is not fully corrupted by salt and pepper noise instead of some pixel values are changed in the image. Although in noisy image, there is a possibilities of some neighbours does not changed. This noise is seen in data transmission. Image pixel values are replaced by corrupted pixel values either maximum ‘or’ minimum pixel value i.e., 255 ‘or’ 0 respectively, if number of bits are 8 for transmission.

3.1.2 Minimum Mean Square Error (MMSE)

MMSE is more effectively used to estimate in a Bayesian setting with quadratic cost function. The main idea behind the Bayesian approach for estimation where in frequent prior information is available on the parameter to be computed. For example, when a new observation is made available, old estimate of the parameter can be revised. This is against to the non-Bayesian approach like Minimum-Variance Unbiased Estimator (MVUE) wherein actually nothing is presumed to be identified about the parameter in advance.
and which do not account for such platforms. Such prior information is captured by the prior probability density function of the parameters in the Bayesian approach. Directly based on Bayes theorem, provisions allows to go for making better posterior estimates as huge number of observations are available.

### 3.1.3 Peak Signal-to-Noise Ratio (PSNR)

The engineering term ‘peak signal–to-noise ratio’ for the ratio between the maximum possible power of a signal and the power of computing noise that affects the fidelity of its representation. Since many signals have a very wide dynamic range, PSNR is usually mentioned in terms of the logarithmic decibel scale. PSNR is hugely implemented to judge image quality based on the MSE measure. This measurement is a pixel-wise error metric that indicates the quality degradation. PSNR is most easily defined via the mean squared error (MSE). Given a noise-free m×n monochrome image I and its noisy approximation K, MSE is defined as:

\[
MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i, j) - K(i, j)]^2
\]  

(3.1)

The PSNR (in dB) is defined as:

\[
PSNR = 10 \cdot \log_{10} \left( \frac{MAX_I^2}{MSE} \right)
\]

Here, MAX$_I$ is the maximum possible pixel value of the image. MAX$_I$ is 255, when the pixels are represented using 8 bits per sample. In general, MAX$_I$ is $2^B - 1$, when samples are represented using linear PCM with B bits per sample. The definition of PSNR is same in respect of color image with three RGB values per pixel except the MSE is the sum over all squared
value differences divided by image size and by three. On the other hand, for color images the image is converted into different color space and PSNR is reported against each and every channels of that color space.

3.1.4 Structural Similarity (SSIM)

For measuring the similarity between the two images SSIM is used. On the other hand, SSIM is a full reference metric for the measuring of images quality based on an initial uncompressed or distortion-tree image as reference.

It is designed to better traditional methods such as PSNR and MSE which were proved to be inconsistent with human eye perception. The difference in regard to other technique noted earlier such as MSE or PSNR is that these approaches estimate absolute errors. Alternatively, SSIM is a perception based model that considers image degradation as the expected change in structural information while also inserting main perceptual phenomena including both luminance masking and contrast masking terms.

Structural information is the thinking that the pixels have strong inter-dependencies particularly where they are very close. There dependencies will go with main information about the structure of the objects in the visual scene. In the phenomena of luminance masking, the image distortions tend to be less visible in bright regions, while in phenomena of the contrast masking, thereby distortions will become less visible when there is texture in the image.

This formula is applied only on luma samples in order to evaluate the image quality. The resulting SSIM index is a decimal value between -1 and +1, and value +1 is only reachable in the case of two identical sets of data. It is typically calculated on window sizes of 8×8.
The SSIM metric is calculated on various windows of an image. The measure between two windows \( x \) and \( y \) of common size \( N \times N \) is:

\[
SSIM (x, y) = \frac{(2\mu_x \mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}
\]

(3.2)

with \( \mu_x \) the average of \( x \);
\( \mu_y \) the average of \( y \);
\( \sigma_x^2 \) the variance of \( x \);
\( \sigma_y^2 \) the variance of \( y \);
\( \sigma_{xy} \) the covariance of \( x \) and \( y \);
\( c_1 = (k_1 L)^2 \),
\( c_2 = (k_2 L)^2 \) two variables to stabilize the division with weak denominator;
\( L \) the dynamic range of the pixel-values (typically this is \( 2^{\#\text{bits per pixel}} - 1 \));
\( k_1 = 0.01 \) and \( k_2 = 0.03 \) by default.

### 3.1.5 Filter

Filtering in image processing is a basis function that is used to achieve many tasks such as noise reduction, interpolation, and re-sampling. Filtering an image data is a standard process used in almost all image processing systems. The choice of filter is determined by the nature of task performed by filter and behavior and type of data. Filters are used to remove noise from digital image while keeping details of the image preserved is a necessary part of image processing.
In the category of filtering without detection, there is a window mask which is moved across the 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 a pixel of concern. When the mask starts moving from top left corner to bottom right corner of the image, it perform some arithmetic operations without discriminating any pixel of image.

In the category of detection followed by filtering, two steps are needed. In the first step, noisy pixels of the image is identified and in the second step, those pixels of image which contain noise are filtered. 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.

3.1.5.1 Gaussian filter

A Gaussian filter is a filter whose impulse response is a Gaussian function (or an approximation to it). Gaussian filters have the properties of having no overshoot to a step function input while minimizing the rise and fall time. This behavior is closely connected to the fact that the Gaussian filter has the minimum possible group delay. It is considered the ideal time domain filter. These properties are important in areas such as oscilloscopes and digital telecommunication systems.

3.1.5.2 Average filter

Here the filter computes the average value of the corrupted image in a pre-decided area. Then the center pixel intensity value is replaced by that average value. This process is repeated for all pixel values in the image.
3.1.5.3 Median Filter

The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the ‘window’, which slides, entry by entry, over the entire signal. For 1D signal, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible (such as ‘box’ or ‘cross’ patterns). Note that if the window has an odd number of entries, then the median is simple to define: it is just the middle value after all the entries in the window are sorted numerically.

It is often desirable to be able to produce some type of noise reduction on an image in processing. The median filter is a nonlinear digital filtering technique, very often used to eliminate noise. That type of noise reduction is typical preprocessing step to improve the results of later processing step for instance, edge detection on an image. Median filtering is very repeatedly used in digital image processing because in certain circumstances, it saves edges while removing noise.

In a sample of data, or a finite population, there may be no member of the sample whose value is identical to the median (in the case of an even sample size); if there is such a member, there may be more than one so that the median may not uniquely identify a sample member. Nonetheless, the median can be used as a measure of location when a distribution is skewed, when end-values are not known, or when one requires reduced importance to be attached to outliers, e.g., because they may be measurement errors.

3.1.5.4 Adaptive median filter

The adaptive filter works on a rectangular region $S_{xy}$. The adaptive median filter changes the size of $S_{xy}$ during the filtering operation depending on certain criteria as listed below. The output of the filter is a single value
which replaces the current pixel value at \((x, y)\), the point on which \(S_{xy}\) is centered at the time. The following notation is adapted from the book and is reintroduced here:

\[
\begin{align*}
Z_{\text{min}} &= \text{Minimum gray level value in } S_{xy} \\
Z_{\text{max}} &= \text{Maximum gray level value in } S_{xy} \\
Z_{\text{med}} &= \text{Median of gray levels in } S_{xy} \\
Z_{xy} &= \text{gray level at coordinates } (x, y) \\
S_{\text{max}} &= \text{Maximum allowed size of } S_{xy}
\end{align*}
\]

The adaptive median filter works in two levels denoted Level A and Level B as follows:

Level A:

\[
\begin{align*}
A1 &= Z_{\text{med}} - Z_{\text{min}} \\
A2 &= Z_{\text{med}} - Z_{\text{max}}
\end{align*}
\]

If \(A1 > 0\) AND \(A2 < 0\), Go to level B

Else increase the window size

If window size \(\leq S_{\text{max}}\) repeat level A

Else output \(Z_{xy}\).

Level B:

\[
\begin{align*}
B1 &= Z_{xy} - Z_{\text{min}} \\
B2 &= Z_{xy} - Z_{\text{min}}
\end{align*}
\]

If \(B1 > 0\) And \(B2 < 0\) output \(Z_{xy}\)

Else output \(Z_{\text{med}}\).

The algorithm is used for three main purposes. First is to remove ‘Salt and Pepper’ noise, second is to smoothen any non impulsive noise and third is to reduce excessive distortions such as too much thinning or thickening of object boundaries.
3.2 PREPROCESSING FILTER OF GRAYSCALE/COLOR IMAGES

Figure 3.1 Block diagram of preprocessing filter for different noises

There may be a chance of noise to come in real time. Depends on real time scenario it is focused to add different kind of noise. Noise can be additive or multiplicative. Additive noise further classified into Gaussian noise, salt and pepper noise, random noise. Multiplicative noise is speckle noise. Gray Scale Image or color image was taken for processing. If the input image is color, then it is converted into grayscale image. A color image has three components namely y-luminance, Cb-chrominance for blue, Cr-chrominance for red. After applying RGB to grayscale only y samples out of three inputs Y, Cb, Cr is obtained by skipping Cb, Cr pixels. Noise was generated in the Sigma value ranging between 0.1 and 0.05.

Random number is generated between the range of 0 to 255. 0 represents value of black pixel, 127 represents value of gray pixel, 255 represents value of white pixel. It means that a random number will generate pixels within range of black to white pixels. Each pixel in the noisy image will have some random number between the range 0 to 255. \( N(X) \times \Sigma \) is general noise function where \( \Sigma \) indicates value ranging from 0.1 to 0.05 and \( n(x) \) is a value from 0 to 1. Highest value of sigma gives more noisy and lowest value of sigma gives less noise. Noise function is nothing but noise generation algorithm which will be varying for salt and pepper noise, speckle noise, random noise, Gaussian noise.
The generated noise was added to the original input image to obtain noisy image. 0 to 255 is unsigned integer which is converted to double format which is ranging from 0 to 1 where 0 indicates black pixel value, 0.5 indicates gray pixel value, 1 indicates white pixel value. The entire image has to be converted into double format which has pixel values between 0 and 1. Since Noise is in double format, input image has to be converted to double format for summing of both noisy image and input image. Noise is added to input image to obtain noisy image.

Filter is applied to noisy image to enhance certain features in the data and to remove noise from image, the image is subjected to different processing operations which involve changing the quality of an image in order to improve the pictorial information of an image for human interpretation, render the image should be more suitable for independent machine perception. The following equation is used to obtain noise free image from the noisy image.

\[
\text{Reconstructed image} = \sum h(m,n) \times x(m,n)
\]

Where \( h(m,n) \) represents filter coefficients

and \( x(m,n) \) represents noisy image

Thus Filter is applied to the noisy image to reconstruct the original image from noisy image. The filter coefficient values may be varying for different filters like Gaussian filter, average filter, median filter, adaptive median filter. This filtering process helps in maximize the clarity, sharpness of image and details of features of interest towards extraction of information & further analysis. The working of filter is depicted in the figure 3.1.

In the first stage, the original input image is compared with noisy image and Objective measurement parameters like PSNR-P1, MMSE-M1,
SSIM-S1 and ENERGY RATIO-E1 were obtained. In the comparison of Original image with noisy image, the filter performance parameters have been PSNR, MMSE, ER, SSIM referred to as P1, M1, S1, E1 respectively.

In the second stage, the noisy image is compared with filtered output image; Objective measurement parameters like PSNR referred as P2, MMSE referred as M2, SSIM referred as S2 and ENERGY RATIO referred as E2 were obtained.

The obtained performance parameters in both stages are compared. It is ensured that as P2>P1, M2<M1, S2>S1, E2>E1 which implied that the filtered output image gave good visual quality and less MMSE and appropriate SSIM and ER when compared to noisy image.

3.3 RESULTS AND DISCUSSION

Gaussian Noise (Amplifier Noise) 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 is nothing but normal noise model. This model is additive in nature and follows Gaussian distribution. Each pixel in the noisy image is the sum of true pixel value in the noisy image and random, Gaussian distributed noise value. At each point, the noise is independent of intensity of pixel value. The PDF of Gaussian random variable is given by: $P(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2 / 2\sigma^2}$, $-\infty < 0 < \infty$ where: $P(x)$ is the Gaussian distribution noise in image; $\mu$ and $\sigma$ is the mean and standard deviation respectively.

In many cases, noise in digital images is detected to be additive in nature with uniform power in the whole bandwidth and with Gaussian probability distribution. It can be referred to as Additive White Gaussian Noise (AWGN). Suppressing AWGN is rather difficult as it corrupts almost
all pixels in an image. To eradicate noise without excessive smoothing of major details, a de-noising technique needs to be spatially adaptive. Depending on the noise model, various techniques are attempted. The wavelet naturally facilitates such spatially adaptive noise filtering due to the properties such as edge detection and multi resolution. Median filters are good for Gaussian noise and uniform noise.

AWGN noise is added with original image of grayscale cameraman image as shown in Figure 3.2 (left), and AWGN noisy image of grayscale cameraman image as shown in Figure 3.2 (right) is generated this is done to compare original image and noisy image and thus to compute objective measurement parameters. These parameters have been found to be as PSNR=28.1191, MSE = 101, ER=0.99438, SSIM=0.63213.

![Figure 3.2 Original image and AWGN noisy image in preprocessing](image)

AWGN noisy image is reconstructed with Gaussian filter. AWGN noisy image is compared with Gaussian filtered output image to get objective measurement parameters and they have been found to be at the values PSNR=32.482, MSE = 68, ER=1.0098, SSIM=0.76095.
In this comparison, it is observed that the PSNR value is increased from 28 to 32.482 and MSE value is reduced from 101 to 68, ER ranging between 0.99 to 1.0098 and SSIM getting increased from 0.63 to 0.76095 which is close to 1. Therefore preprocessing the input image with Gaussian filter gives better image quality compared to unprocessed image.

AWGN noisy image is reconstructed with Average filter. AWGN noisy image and Average filtered output image are compared to find the values at which they change as exhibit fixed changes. To do so, objective measurement parameters are found to be PSNR=32.4262, MSE =210, ER=1.028, SSIM=0.78896.

In this comparison, it is observed that the PSNR value is increased from 28 to 32.4262 and but MSE is not reduced and is increased from 101 to 210 ER comes from 0.99 to 1.028 and SSIM is increased from 0.63 to 0.78896 which is close to 1. Also Average filter gives better objective measurements for image quality parameters than Gaussian filter. Therefore preprocessing the input image with average filter gives better image quality compared to unprocessed image. Since MSE not reduced with average filter, noisy image is preprocessed with another filter. Using median filter, noise in AWGN noisy image is removed. In comparison with AWGN noisy image with Median filtered output image, objective measurement parameters are computed as PSNR=35.5768, MSE =44, ER=1.0131, SSIM=0.77695.

In this comparison, it is verified that the PSNR value is increased 28 to 35.5768 and MSE reduced from 101 to 44 ER comes from 0.99 to 1.0131 which is near to 1 and SSIM is increased from 0.63 to 0.77695 which is also close to 1. Also Median gives filter better objective measurements for image quality parameters than average filter. Therefore preprocessing the input image with median filter gives better image quality compare than average filter, Gaussian filter to some extent. Still little bit improvement needed for
SSIM parameter. So input image is intended for preprocessing with another filter.

AWGN noisy image is reconstructed with Adaptive Median filter. In comparison of AWGN noisy image with Adaptive Median filtered output image, objective measurement parameters are computed as PSNR=36.497, MSE =144, ER=1.0131, SSIM=0.78216.

When comparing AWGN noisy image with Adaptive Median filtered output image it can be seen that the PSNR value is increased from 28 to 36.497 and MSE not reduced from 101. ER coming from .99 to 1.0131 which is near to 1 and SSIM increasing from 0.63 to 0.7216 which is also close to 1. Thus it can be that Adaptive Median filter give much improved PSNR value for and better image quality parameters than median filter. Therefore preprocessing the input image with adaptive median filter can be said to give better quality of image when compared to Gaussian, average, median filter. Thus for AWGN noise, performance of filters are analysed and it is ensured that AMF outperforms. For other noises also, performance of filters are analysed in the following sections.

Histograms for grayscale cameraman image with and without AGWN noise are drawn. In general 0 represents black pixel, 127 represents gray pixel 255 represents white pixel. In histogram images, leftmost values of x-axis represents pixels having low intensity values and middle values of x-axis represents pixels having medium intensity values, rightmost values of x-axis represents pixels having high intensity values. During filtering process loosing low and high valued pixels is not a matter to be concerned. However, pixels having medium intensity values between 0 to 255 have been found to be the main content of the image and this evaluating quality of the image.
Histogram of original image of grayscale cameraman image is compared with histogram of and AWGN noise-free image filtered by different filters such as Gaussian filter, average filter, median filter, adaptive median filter and it is noticed that adaptive medium filter not losing medium valued pixels and it is found that the speckle noisy image reconstructed by adaptive medium filter gives good visual quality. The comparison of histogram of original image of grayscale cameraman image and histogram of adaptive median filtered image of grayscale cameraman image for AWGN noise is shown in figure 3.3.

Comparison of filter performance parameters of different filters for grayscale cameraman image with respect to AWGN noise in preprocessing side before compression-decompression is shown in Table 3.1 and it is found that adaptive median filter gives high PSNR value, less MSE, better ER, appropriate SSIM value.
Table 3.1  Comparison of filter parameters of gray scale image for AWGN noise in pre-processing

<table>
<thead>
<tr>
<th>Noise Type /Filters</th>
<th>PSNR</th>
<th>MSE</th>
<th>Energy Ratio</th>
<th>MAXERR</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grayscale cameraman image with AWGN Noise</td>
<td>28.0991</td>
<td>100.7331</td>
<td>0.9946</td>
<td>44.3551</td>
<td>0.6325</td>
</tr>
<tr>
<td>Gaussian Filter Output Image</td>
<td>32.4820</td>
<td>67.4698</td>
<td>1.0098</td>
<td>65.3837</td>
<td>0.7610</td>
</tr>
<tr>
<td>Average Filter Output Image</td>
<td>32.4262</td>
<td>209.1787</td>
<td>1.0280</td>
<td>142.8303</td>
<td>0.7890</td>
</tr>
<tr>
<td>Median Filter Output Image</td>
<td>35.5768</td>
<td>143.5727</td>
<td>1.0131</td>
<td>192.9070</td>
<td>0.7770</td>
</tr>
<tr>
<td>AMF Output Image</td>
<td>36.4970</td>
<td>143.5727</td>
<td>1.0131</td>
<td>192.9070</td>
<td>0.7822</td>
</tr>
</tbody>
</table>

From the Table 3.1, it can be understood that after the removal of AWGN noise from AWGN noisy image using different filtering techniques, the parameter values computed seen to varying. It is found that the filtered image by other filters having better PSNR values along with other parameters when compare to AWGN noisy image. However, of all the filtering process, adaptive median filter is good and the output received is under to have a better quality of image because PSNR is high.

Speckle noise: Modeling of this noise can be taken by random value multiplications with pixel values of the image and can be expressed as $J=I+N*I$ where $J$ is the speckle noise distribution in image, $I$ is the speckle input image and $N$ is the uniform noise image by mean $o$ and variance $v$. Quality of the active radar and synthetic aperture radar (SAR) images will be deterioted by this noise. Originate of this noise is because of coherent processing of back scattered signals from multiple distributed points. This
type of noise is present in the conventional radar system when the returned signal from the object having size less than or equal to a single image processing unit indicates sudden fluctuations.

Speckle noise is added with original image of grayscale cameraman image as shown in figure 3.4(left), and thus Speckle noisy image of grayscale cameraman image as shown in figure 3.4(right) is produced in which the original image and speckle noisy image both are compared and objective measurement parameters are computed as PSNR=25.6057, MSE = 179, ER=0.99278, SSIM=0.01004.

The speckle noisy image is changed by using Gaussian filter and the image got is compared with the original image for getting objective measurement parameters as PSNR=33.1563, MSE = 100, ER=1.0105, SSIM=0.70244.

Figure 3.4 Original Image and Speckle Noisy Image in preprocessing
Speckle noisy image is reconstructed for the removal of noise by using Average filter. In comparison of speckle noisy image with Average filtered output image, objective measurement parameters are computed as PSNR=32.8493, MSE = 220, ER=1.0301 , SSIM=0.74574.

In speckle noisy image, when noise is removed with Median filter, speckle noisy image is compared with Median filtered output image and objective measurement parameters are found to be as PSNR=29.8782, MSE =178, ER=1.0213 , SSIM=0.67947.

From the speckle noisy image, noise is removed using the Adaptive Median filter. While comparing speckle noisy image with Adaptive Median filtered output image, objective measurement parameters are computed as PSNR=34.7676, MSE = 178, ER=1.0213, SSIM=0.69009.

Histograms are drawn for grayscale cameraman image with and without speckle noise, filtered output images and loss of information found. During filtering process loosing low and high valued pixels is not a matter to be concerned. However, pixels have medium intensity values between 0 to 255 have been found to be the main content of the image and this evaluating quality of the image. Loosing medium valued pixels will affect the visual quality of picture.

Histogram of original image of grayscale cameraman image is compared with histogram image of noise–free image filtered by different filters such as Gaussian filter, average filter, median filter, adaptive median filter. The comparison of histogram of original image of grayscale cameraman image with adaptive median filtered image of grayscale cameraman image for speckle noise is shown in figure 3.5 and it is observed that adaptive medium filter not loosing medium valued pixels and it is found that reconstructed image by adaptive medium filter gives good visual quality.
Figure 3.5  Histogram of Original and AMF output for Speckle Noise

For example comparison of histogram of original image and histogram of adaptive median filtered image for Speckle Noise is shown in Figure 3.5. Comparison of filter performance parameters of different filters for grayscale cameraman image with respect to speckle noise in preprocessing side before compression-decompression is shown in Table 3.2 and it is ensured that Adaptive Median Filter gives high PSNR value, less MSE, better ER, appropriate SSIM value.

From the Table 3.2, it can be understood that after the removal of speckle noise from speckle noisy image using different filtering techniques, the parameter values computed seen to varying. However, of all the filtering process, Adaptive median filter is good and the output received is under to have a better quality image because PSNR is high also, it is found that the filtered image having better PSNR values along with other parameters.
Table 3.2  Comparison of filter parameters of gray scale image for speckle noise in pre-processing

<table>
<thead>
<tr>
<th>Noise Type /Filters</th>
<th>PSNR</th>
<th>MSE</th>
<th>Energy Ratio</th>
<th>MAXER</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grayscale cameraman image with Speckle Noise</td>
<td>25.6057</td>
<td>178.8594</td>
<td>0.9928</td>
<td>43</td>
<td>0.0100</td>
</tr>
<tr>
<td>Gaussian Filter Output</td>
<td>33.1563</td>
<td>99.9928</td>
<td>1.0105</td>
<td>69</td>
<td>0.7024</td>
</tr>
<tr>
<td>Average Filter Output Image</td>
<td>32.8493</td>
<td>219.1137</td>
<td>1.0301</td>
<td>143</td>
<td>0.7457</td>
</tr>
<tr>
<td>Median Filter Output Image</td>
<td>29.8782</td>
<td>177.5321</td>
<td>1.0213</td>
<td>198</td>
<td>0.6795</td>
</tr>
<tr>
<td>AMF Filter Output Image</td>
<td>34.7976</td>
<td>177.5321</td>
<td>1.0213</td>
<td>198</td>
<td>0.6901</td>
</tr>
</tbody>
</table>

In this process, the original image of grayscale cameraman image is correlated to a form of image by the addition of random noise. The original image of grayscale cameraman image and random noisy image of grayscale cameraman image both are compared and objective measurement parameters obtained are PSNR=25.0594, MSE = 203, ER=0.98924, SSIM=0.50889. Random noisy image is filtered using Gaussian filter for the removal of noise. In comparison of random noisy image with Gaussian filtered output image, objective measurement parameters are found to be at the different values in PSNR=29.7121, MSE =110, ER=1.0076, SSIM=0.64524.
The random noisy image and the image retrieved using average filter are compared and the parameters have been found to be at the different values in PSNR=31.4936, MSE =222, ER=1.0276, SSIM=0.73416.

The random noisy image is allowed to go for the removal of noise using the median Filter. The images thus found are compared and parameter values have thus been calculated at PSNR = 33.0392, MSE = 166, ER = 1.014, SSIM = 0.70277.

Random noisy image is allowed to undergo to change by using the Adaptive median filter for removal of the noise. While comparing the random noisy image with Adaptive median filtered output image, and computing objective measurement parameters is seen that PSNR stands at 33.487, MSE stands at 166, ER stands at 1.014 , SSIM stands at 0.70826

From the histograms of grayscale cameraman image with and without random noise, four filtered output images, it can be estimated that the pixels with low and high values ranging between 0 to 255, the pixel with 0
value indicating black pixel, the pixel with 0 value indicating white pixel. During filtration process, loosing black pixels and white pixels is not a matter to be concerned. However, pixels have medium intensity values between 0 to 255 have been found to be the main content of the image and this evaluating quality of the image. Loosing medium valued pixels will affect the visual quality of picture.

Histogram of original image of grayscale cameraman image is compared with histogram of random noise–free image filtered by different filters such as Gaussian filter, average filter, median filter, adaptive median filter. The comparison of histogram of original image of grayscale cameraman image is compared with histogram of adaptive median filtered image of grayscale cameraman image for random noise is shown in figure 3.7 and it is observed that Adaptive medium filter not loosing medium valued pixels and it is found that reconstructed image by adaptive medium filter gives good visual quality.

Figure 3.7  Histogram of Original and AMF output for random noise
Comparison of filter performance parameters of different filters for grayscale cameraman image with respect to random noise in preprocessing side before compression-decompression is shown in Table 3.3 and it is found that Adaptive Median Filter gives high PSNR value, less MSE, better ER, and appropriate SSIM value.

From the Table 3.3, it can be understood that after the removal of random noise from noisy image using different filtering techniques, the parameter values computed seen to varying. However, of all the filtering process, Adaptive Median Filter is good and the output received is under to have a better quality image because PSNR is high also, it is found that the filtered image having better PSNR values along with other parameters.

Table 3.3  
Comparison of filter parameters of gray scale image for random noise in pre-processing

<table>
<thead>
<tr>
<th>Noise Type /Filters</th>
<th>PSNR</th>
<th>MSE</th>
<th>Energy ratio</th>
<th>MAXERR</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grayscale cameraman image with Random Noise</td>
<td>25.0594</td>
<td>202.8352</td>
<td>0.9892</td>
<td>56.8186</td>
<td>0.5089</td>
</tr>
<tr>
<td>Gaussian Filter Output</td>
<td>29.7121</td>
<td>109.6790</td>
<td>1.0076</td>
<td>60.6594</td>
<td>0.6452</td>
</tr>
<tr>
<td>Average Filter Output Image</td>
<td>31.4936</td>
<td>221.0408</td>
<td>1.0276</td>
<td>138.0273</td>
<td>0.7342</td>
</tr>
<tr>
<td>Median Filter Output Image</td>
<td>33.0392</td>
<td>165.3227</td>
<td>1.0140</td>
<td>195.6642</td>
<td>0.7028</td>
</tr>
<tr>
<td>AMF Filter Output Image</td>
<td>33.4870</td>
<td>165.3227</td>
<td>1.0140</td>
<td>195.6642</td>
<td>0.7083</td>
</tr>
</tbody>
</table>

The salt-and-pepper noise is also termed ‘impulse noise’ or ‘shot noise’ ‘spike noise’ for this type of noise. It is also referred as independent noise. As a result of this noise, appearance of image having black and white dots and hence salt and pepper noise. Because of sharp and sudden change of
image signal, this noise will arise in the image. This type of noise is caused because of the dust particles in the image acquisition source, overheated faulty components, memory cell failure, and malfunctioning pixel elements in camera sensors or synchronization errors in the process of digitization or transmission. Image is corrupted to a small extent due to noise. In the salt-and-pepper noise, there are only two possible values exists that is a and b and the probability of is less than 0.2. For 8-bit image, the typical value for salt-noise is 255 and pepper-noise is 0.

Figure 3.8 Original image and image with salt and pepper noise in pre-processing

Salt and pepper noise is incorporated to the original image. The original image of grayscale cameraman image as shown in figure 3.8(left) and Salt and pepper noisy image of grayscale cameraman image as shown in figure 3.8(right) both are compared to measure their quality by calculating the picture quality parameters and these values are as PSNR=27.4818, MSE = 117, ER=1.0088, SSIM=0.01014.
From the computed values, the PSNR value is to be very low and the MSE Value to be very high. Therefore Salt and pepper noise has affected heavily the quality of image which will become very poor in appearance.

In this stage, salt and pepper noisy image is changed to an image with no noise using Gaussian filter. The image retrieved by Gaussian filter and salt and pepper noisy image are compared and computed parameters values are found to be standing at PSNR=40.934, MSE =107, ER=1.0098, SSIM=0.82772. The increase in PSNR value the reduced MSE value prove that Gaussian filter process is suitable at some level.

Using average filter the salt and pepper noisy image is allowed to undergo a change and this to produce an image where the noise is removed. Salt and pepper noisy image with average filtered output image are compared to establish the quality, objective measurement parameters values have been computed as PSNR=33.0213, MSE =222, ER=1.0295, SSIM = 0.77309.

Salt and pepper noisy image is allowed to change to be noise removed image through median filter process and the salt and pepper noisy image and noise removed image are compared for measuring quality by calculating the parameter values. Computed parameters are recorded as PSNR=44.3146, MSE = 126, ER=1.0118, SSIM=0.874731. It is thus concluded that median filter process is better than the Gaussian filter, average filter processes as the PSNR value have been found to be higher than earlier ones.

Salt and pepper noisy image is allowed to undergo to change by using the Adaptive median filter for removal of the noise. While comparing the salt and pepper noisy image with Adaptive median filtered output image,
and computing objective measurement parameters is seen that PSNR stands at PSNR=44.432, MSE =126, ER=1.0118, SSIM=0.88013.

It is thus ensured that adaptive median filtered processes is the best filtering process for the reason that PSNR value is the highest and the MSE the least when compared to all the other filtering processes.

![Figure 3.9 Histogram of Original and AMF Output for salt and pepper noise in preprocessing](image)

Histogram of original image of grayscale cameraman image with salt and pepper noise is compared with histogram of Salt and pepper noise–free image filtered by different filters such as Gaussian filter, average filter, median filter, adaptive median filter. The comparison of histogram of original image of grayscale cameraman image with histogram of adaptive median filtered image of grayscale cameraman image for salt and pepper noise is shown in figure 3.9 and it is observed that adaptive medium filter not loosing medium valued pixels and it is found that reconstructed image by adaptive medium filter gives good visual quality. Pixels values have been
found to be at 0 for black pixel and 1 for white pixel and losing black pixels and white pixels not affecting picture clarity.

Loosing medium valued pixels will affect the visual quality of picture. From the histograms as shown in Figure 3.9, it is noted that during filtration process, pixels having medium intensity values between 0 to 255 have been found to be the preserved. Thus maintaining content of the image by adaptive median filter.

Table 3.4 Comparison of filter parameters of grayscale image for Salt and pepper noise in pre-processing

<table>
<thead>
<tr>
<th>Noise Type /Filters</th>
<th>PSNR</th>
<th>MSE</th>
<th>Energy Ratio</th>
<th>MAXERR</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grayscale cameraman image with Salt and pepper Noise</td>
<td>25.31124</td>
<td>191.4062</td>
<td>0.991855167</td>
<td>247</td>
<td>0.010128</td>
</tr>
<tr>
<td>Gaussian Filter Output</td>
<td>40.93399</td>
<td>106.0367</td>
<td>1.009821224</td>
<td>172</td>
<td>0.827722</td>
</tr>
<tr>
<td>Average Filter Output Image</td>
<td>33.02128</td>
<td>221.3326</td>
<td>1.029521242</td>
<td>138</td>
<td>0.773086</td>
</tr>
<tr>
<td>Median Filter Output Image</td>
<td>44.31463</td>
<td>125.4986</td>
<td>1.011830071</td>
<td>199</td>
<td>0.87471</td>
</tr>
<tr>
<td>AMF Filter Output Image</td>
<td>44.43203</td>
<td>125.4986</td>
<td>1.011830071</td>
<td>199</td>
<td>0.880131</td>
</tr>
</tbody>
</table>

The performance parameters of different filters for grayscale cameraman image with respect to salt and pepper noise in preprocessing side before compression-decompression is shown in Table 3.4 and it is found that adaptive median filter gives high PSNR value, less MSE, better ER, appropriate SSIM value.
From the Table 3.4, one can notice the PSNR value increasing and MSE value reducing and Energy Ratio, SSIM being close to 1 for Adaptive Median Filter.

For a color noisy image, a filter is applied for getting luma samples ie, luminance-Y and it is applied for chrominance of blue (Cb) and it is applied for chrominance of red (Cr) separately which ensures the improved visual quality as well as improved objective measurements for color images.

Salt and pepper noise is added with original image of lina-sree color image as shown in figure 3.10(left) and salt and pepper noisy image of lina-sree color image is generated as shown in figure 3.10(right) in which original image of lina-sree color image and salt and pepper noisy image of linasree color image both are compared and objective measurement parameters are computed as PSNR=25.0723, MSE = 203, ER=0.98295, SSIM=0.0056703

![Salt & Pepper Noise in Preprocessing](image-url)

**Figure 3.10** Original color Image and color image with Salt and pepper Noise in preprocessing
Salt and pepper noisy color image is reconstructed with Gaussian filter. When salt and pepper noisy color image and new color image got by Gaussian filter are compared for measuring picture quality and parameters are found to be at PSNR=41.3953, MSE =91, ER=0.9978 , SSIM=0.81809

Salt and pepper noisy color image is allowed to get the noise removed by using average filter and the new noiseless color image and salt and pepper noisy color image are compared by calculating the PSNR and other values and they have been found to be at PSNR = 34.3253, MSE = 72, ER = 1.0105, SSIM=0.7917.

Salt and pepper noisy color image was allowed to undergo a change for the removal of noise. The filter processes used is median filter. The new noise removed image and salt and pepper noisy color image are compared for quality by calculating parameter access and the values recorded are PSNR = 40.218, MSE =30, ER=1.0067 , SSIM=0.8811.

Figure 3.11  Histogram of Original color image and AMF Output in preprocessing
Salt and pepper noisy color image to establish the effective filter is always through a different filtering process and the process used here is the adaptive median filter and thus to produce a new noise removed salt and pepper noisy color image. The two images ie, the salt and pepper noisy color image and the salt and pepper noise removed color image are compared for quality by calculating the parameter values as $\text{PSNR}=42.288$, $\text{MSE} = 30$, $\text{ER}=1.0067$, $\text{SSIM}=0.88013$.

![Image of original and filtered images]

**Figure 3.12** Salt and pepper Noisy lina-sree color Image and Adaptive Median Filtered Lina-sree color image in preprocessing

The comparison of histogram for original image of lina-sree color image and histogram for adaptive median filtered image of lina-sree color image is shown in figure 3.11 and it is observed that pixel with low values and pixel with high values loosing their intensity values. Pixel with medium values are found to be preserved. So image quality thus gets maintained after adopting the adaptive median filter process.
The comparison of filter performance parameters of lina-sree color image for salt and pepper noise in preprocessing side before compression is shown in Table 3.5. After analysis from the table 3.5, it is found that adaptive median filter gives high PSNR value, less MSE, better ER, appropriate SSIM value.

Table 3.5 Comparison of filter parameters of color lina-sree image for Salt and pepper noise in pre-processing

<table>
<thead>
<tr>
<th>Noise Type /Filters</th>
<th>PSNR</th>
<th>MSE</th>
<th>Energy ratio</th>
<th>MAXERR</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lina color image with Salt and pepper Noise</td>
<td>25.0723</td>
<td>202.2334</td>
<td>0.9829</td>
<td>255</td>
<td>0.0057</td>
</tr>
<tr>
<td>Gaussian Filter Output</td>
<td>41.3953</td>
<td>90.2190</td>
<td>0.9978</td>
<td>181</td>
<td>0.8181</td>
</tr>
<tr>
<td>Average Filter Output</td>
<td>34.3253</td>
<td>71.5676</td>
<td>1.0105</td>
<td>114</td>
<td>0.7917</td>
</tr>
<tr>
<td>Median Filter Output Image</td>
<td>40.2180</td>
<td>29.3300</td>
<td>1.0067</td>
<td>197</td>
<td>0.8811</td>
</tr>
<tr>
<td>AMF Filter Output Image</td>
<td>42.2880</td>
<td>29.3300</td>
<td>1.0067</td>
<td>197</td>
<td>0.8801</td>
</tr>
</tbody>
</table>

For colored images, from the above table, it can be concluded that PSNR value remains the highest only when adaptive median filter process is used and the MSE value remains highly low in the same process. Therefore it concluded that Adaptive Median Filter is the best de-noising filtering technique.

Similarly the performance of filter is tested further in post-processing after compression-decompression for grayscale images and color images. Thus Adaptive Median Filter is proved as best de-noising technique. It means that image picture quality is improved using preprocessing filter and
ensures that minimum mean squared error is less, structural similarity index, energy ratio are better compare to noisy image.

Salt and pepper noisy image of grayscale cameraman image as shown in figure 3.12(left) is compared with decompressed image of grayscale cameraman image as shown in Figure 3.12 (right) in which noisy image and decompressed image both are compared and objective measurement parameters are computed as PSNR=26.8004, MSE = 136, ER=1.013 , SSIM=0.84253.

Figure 3.13  Grayscale cameraman image with Salt and pepper Noise and decompressed image in post-processing

In this stage, the decompressed image is allowed to go through with the Gaussian filter to remove the degradation and the image thus got is compared with salt and pepper noisy image for the quality measurement by computing parameter values as PSNR= 63.7706, MSE =151, ER=1.021, SSIM=0.83784.

In this process, degradation is removed by using average filter and salt and pepper noisy image is compared with average filtered image of
decompressed image for the quality measurement by computing different parameter values, and these values are found to be as PSNR = 63.5781, MSE = 245, ER = 1.0337, SSIM = 0.8052.

Decompressed image is filtered by using median filter for removing degradation and the image thus retrieved image is compared with salt and pepper noisy image by computing objective measurement parameters as PSNR = 63.8489, MSE = 160, ER = 1.0166, SSIM = 0.83553.

The decompressed image is allowed to go through a process for removing the degradation using the adaptive median filter as shown in Figure 3.13. In comparison of salt and pepper noisy image with adaptive median filtered image of decompressed image, objective measurement parameters are noted as PSNR = 76.456, MSE = 160, ER = 1.0166, SSIM = 0.82977.

![Histogram of Original and AMF Output in postprocessing](image_url)
The comparison of histogram for original image of grayscale cameraman image and histogram for decompressed image post-processed by adaptive median filter for salt and pepper noise is shown in figure 3.13. and the pixel with low and high values are noticed missing and pixel with medium values getting maintained and thus the image not loosing its visual quality in the post-processed image of decompressed image.

Table 3.6 Comparison of filter parameters of decompressed grayscale cameraman image in post-processing

<table>
<thead>
<tr>
<th>Noise Type /Filters</th>
<th>PSNR</th>
<th>MSE</th>
<th>Energy Ratio</th>
<th>MAXERR</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grayscale cameraman image with Salt and pepper noise</td>
<td>26.8004</td>
<td>135.8434</td>
<td>1.0130</td>
<td>193</td>
<td>0.8425</td>
</tr>
<tr>
<td>Gaussian Filter Output</td>
<td>63.7706</td>
<td>150.0729</td>
<td>1.0210</td>
<td>194.2012</td>
<td>0.8378</td>
</tr>
<tr>
<td>Average Filter Output</td>
<td>63.5781</td>
<td>244.2966</td>
<td>1.0337</td>
<td>197.6667</td>
<td>0.8052</td>
</tr>
<tr>
<td>Median Filter Output Image</td>
<td>63.8489</td>
<td>159.6870</td>
<td>1.0166</td>
<td>201.0000</td>
<td>0.8355</td>
</tr>
<tr>
<td>AMF Filter Output Image</td>
<td>76.4560</td>
<td>159.6870</td>
<td>1.0166</td>
<td>201.0000</td>
<td>0.8298</td>
</tr>
</tbody>
</table>

The comparison of filter performance parameters of grayscale cameraman image for salt and pepper noise in post processing side after compression-decompression is shown in Table 3.6 and it is observed that adaptive median filter gives high PSNR value, less MSE, better ER, appropriate SSIM value. From the Table 3.6 it is understood that the adaptive median filter processing works in favour of producing high quality image as the PSNR value is found to be highly increased and the PSNR have been increasing in high value with difference of nearly 40 between noisy image and filtered images.
Salt and pepper noisy Lina Sree color image as shown in figure 3.14(left) is compared with decompressed image of Lina Sree color image as shown in figure 3.14(right) and objective measurement parameters are computed as PSNR=25.0493, MSE =204, ER=0.86518, SSIM=0.86244.

![Salt n Peppers PSNR=25.0493 MSE=204 ER=0.86518 SSIM=0.86244](figure314.png)

**Figure 3.15 color image with Salt and pepper noise and decompressed color Image in post-processing**

The decompressed color image is allowed to undergo the post process for removing degradation using the different filtering process. When Gaussian filter is used to remove degradation from decompressed color image, the obtained filtered image is compared with noisy image and objective measurement parameters are found to be PSNR=81.8269, MSE =213, ER=0.86592, SSIM=0.84832.

While using average filter for degradation removing process, objective measurement parameters have been noted to be at PSNR=77.9058, MSE =248, ER=0.87994, SSIM=0.84171. When median filter is used and the image received compared for quality by computing the parameter values as PSNR=81.6125, MSE =213, ER=0.86592, SSIM=0.84307.
This adaptive median filtering process is found to be the best filtering technique as the objective measurement parameters values indicated as PSNR=81.8269, MSE =213, ER=0.86592, SSIM=0.84832 and it is concluded that adaptive median filter is best suitable for post processing the color image.

Table 3.7 Comparison of filter parameters of decompressed color image for salt and pepper noise in post-processing

<table>
<thead>
<tr>
<th>Noise Type /Filters</th>
<th>PSNR</th>
<th>MSE</th>
<th>Energy Ratio</th>
<th>MAXERR</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lina color image with Salt and pepper noise</td>
<td>25.0493</td>
<td>203.3080</td>
<td>0.8652</td>
<td>197</td>
<td>0.8624</td>
</tr>
<tr>
<td>Gaussian Filter Output</td>
<td>80.8133</td>
<td>197.8428</td>
<td>0.8706</td>
<td>158.8767</td>
<td>0.8653</td>
</tr>
<tr>
<td>Average Filter Output</td>
<td>77.9058</td>
<td>247.1040</td>
<td>0.8799</td>
<td>126</td>
<td>0.8417</td>
</tr>
<tr>
<td>Median Filter Output Image</td>
<td>81.6125</td>
<td>212.9347</td>
<td>0.8659</td>
<td>197</td>
<td>0.8431</td>
</tr>
<tr>
<td>AMF Filter Output Image</td>
<td>81.8269</td>
<td>212.9347</td>
<td>0.8659</td>
<td>197</td>
<td>0.8483</td>
</tr>
</tbody>
</table>

The comparison of filter performance parameters of linasree color image for salt and pepper noise in postprocessing side after compression-decompression is shown in Table 3.7, it is observed that Adaptive Median Filter gives high PSNR value, less MSE, better ER, appropriate SSIM value

From the Table 3.7 and the values recorded it can be said that Adaptive Median Filter is the highest PSNR value being 81.8269. It can also be proved that the other filtering processes also contribute to the degradation removal process at different values.
To estimate the performance analysis of Gaussian Filter, Average Filter, Median Filter, Adaptive Median Filter, the quality parameters such as PSNR, MSE, Energy Ratio, MAXERR, SSIM are calculated for a given image. Performance of four different filters is tested against AWGN noise, speckle noise, random noise and salt and pepper noise which is generated or injected during image capturing or transferring image from scanner to computer. Experiments are conducted using Matlab 7.12.0.635 (R20011a). Clinical dataset of grayscale images, color images with image size of 256 × 256 pixels are taken as input image. Here 2D images are taken and dimension of original and noisy image are same. Noisy image is given as input to all the four different filters.

![Comparison of filter performance for AWGN noise](image)

**Figure 3.16 Comparison of filter performance for AWGN noise**
Figure 3.17 Comparison of filter performance for speckle noise

Figure 3.18 Comparison of filter performance for random noise
Figure 3.19 Comparison of filter performance for salt and pepper noise

Figure 3.20 Comparison of filter for color Lina image in pre-processing
Figure 3.21 Comparison of filter for cameraman image in post processing

Figure 3.22 Comparison of filter for color lina image in post processing
Figure 3.15 to Figure 3.18 depicts adaptive median filter gives high PSNR when comparing other three filters namely average filter, Gaussian filter, median filter for different kind of noises in pre-processing of grayscale cameraman image. Similarly Figure 3.19 shows adaptive median filter gives high PSNR for lina-sree color image in pre-processing. Figure 3.20 and Figure 3.21 shows adaptive median filter gives high PSNR for decompressed grayscale cameraman image and decompressed color lina-sree image in post-processing.

3.4 CONCLUSION

In this analysis, different Filters are used for picture quality evaluation. Picture quality measures such as PSNR, MSE, ER and SSIM are used for evaluation upon comparison of filter performance with respect to four filters for grayscale images and color images. It is found and proved that Adaptive median filter outperforms than other filters and it is the best denoising technique for both preprocessing and post processing of Compressed-Decompressed images.