DENOISING OF SATELLITE IMAGES

A Project Report Submitted in Partial Fulfilment of the Requirements for the Degree of

B. Tech.
(Computer Science and Engineering)

By

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C E R T I F I C A T E

This is to certify that the work in the project entitled *Denoising of Satellite Images* by *Satyabrata Parida* a record of his work carried out under my supervision and guidance in partial fulfilment of the requirements for the award of the degree of *Bachelor of Technology* in *Computer Science and Engineering.*

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C O N T E N T S

ABSTRACT

We use images in our day to day life for keeping a record of information or merely to convey a message. There are a number of parameters which determine the quality of an image or a photograph most of which cannot be solved manually without the help of a computer whatsoever any image that has been captured represents a deteriorated version of the original image. However its clear that by any means we can never get the ideal image which is hypothetical as it is 100% accurate which is not possible. Our aim in image processing is to get the best possible image with minimum number of errors. In order to come to the conclusion of a certain task the correction of this deteriorated version is of optimal importance. Rectifying too much lighting effects, instance noising, geometrical faults, unwanted colour variations and blur are some of the important parameters we need to attend to in order to get a good and useful image. In this paper, the deterioration of images because of noising has been addressed. Noise is any undesired information which adversely affects the quality and content of our image. Primary factors responsible for creating noise in an image are the medium through which photograph is taken (climatic and atmospheric factors like pressure and temperature), the accuracy of the instrument used to take the photograph (for instance camera) and the quantization of data used to store the image.

This noise can be removed by an image processing technique called Image restoration. Image restoration process is concerned with the reconstruction of the original image from a noisy one. That is it tries to perform an operation on the image as the inverse of the imperfections in the image formation system. Degraded image can be perfected by various processes which are actually the reverse of noising. These filtering techniques are very simple and can be applied very easily through software. Some filtering processes have better performance than the others. This depends on the type of noise the image has. These filters are used in a variety of applications efficiently in pre-processing module. In this paper, the restoration performance of *Arithmetic mean filter, Geometric mean filter and Median filter* have been analyzed. The performance of these filters is analyzed by applying it on satellite images which are affected by *Impulse noise, Speckle noise and Gaussian noise*. Since the satellite images are being corrupted by various noises, the satellite images are considered in this paper to analyze the performance of arithmetic mean filter, geometric mean filter and median filter.

By observing the obtained results and PSNR value for various satellite images under different noises, we have recorded the following conclusion.

• the median filter gives better performance for satellite images affected by impulse noise than

arithmetic mean filter and geometric mean filter.

•the arithmetic mean filter gives better performance for gaussian noise than median filter and

geometric mean filters for all satellite images.

•the arithmetic mean filter gives better performance for speckle noise than median filter and geometric mean filter for all satellite images.

Median Filter is an image filter that is more effective in situations where white spots and black spots appear on the image. For this technique the middle value of the m×n window is considered to replace the black and white pixels.After white spots and black spots appear on the image, it becomes pretty difficult to find which pixel is the affected pixel. Replacing those affected pixels with AMF, GMF and HMF is not enough because those pixels are replaced by a value which is not appropriate to the original one. It is observed that the median filter gives better performance than AMF and GMF for distorted images. The performance of restoration filter can be increased further to completely remove noise and to preserve the edges of the image by using both linear and nonlinear filter together.

Chapter 1: Introduction

1.1 Brief History

- Since the dawn of time humans were interested in space and the clestial bodial it contains. But the first non futile trial in this regard was made in 1935. Explore II a big balloon was sent through the atmosphere. It was 22 km or 13.7 miles up above the earth surface.
- The sub orbital flights were introduced in the mid forties. They were the first to take some actual usable images. On October 24, 1946 United States launched such a flight named V-2 . It had the ability to take two images every three seconds. While in its orbit the farthest it could move apart from earth surface was 105 km (65 miles).

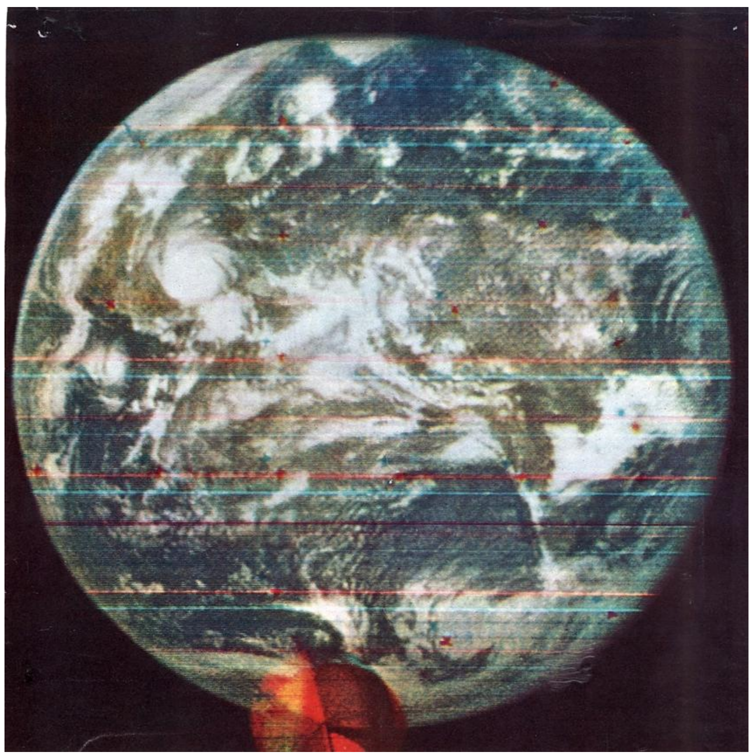


Figure1.1 First non black and white image of the earth from outer space (by Dodge Satellite)

1.2 Definition of Satellite Imagery:

Satellite imagery consists of images of Earth or any other celestial masses floating in the space captured by means of artificial satellites orbiting around them. It doesn't consist of images taken from a stationary source or any vehicle in a state of projectile.

1.3 Applications of Satellite Imagery can be summed up under following major areas:

- In Meteorological Dept.
- For Agricultural purpose
- For Geological studies
- For Forestry
- For Mass Landscaping
- For Conserving Biodiversity
- For Regional Planning
- For Educational Purposes
- By Intelligence Agencies
- During warfare

We capture images so that we can store or display valuable and meaningful graphical information. However there are several defects in image capturing and image storing processes. As a result the picture we obtain is a deteriorated version of the original scene. But we need to extract data from the captured deteriorated image or we need to derive a certain conclusion from it. Hence we need to rectify the image so that it can get as close to the original image as possible. This is a very vital part in the field of image processing.

1.4 Reasons for Degradation

The degradation consists of two distinct phenomenons:

- *Blur*
- *Noise*

1.4.1 Reasons for Blurring

The blur may be due to a number of reasons such as:

- *Motion:*

  Relative motion in between the capturing device and the object being captured is a major cause for blur.

- *Defocusing:*

  If there is a fault in the capturing device and it fails to set its focus perfectly then because of defocusing blur is experienced.

- *Atmospheric Turbulence:*

  The atmospheric conditions such as temperature, pressure, humidity, weather conditions etc. are also responsible for causing blur.[1]

1.4.2 Reasons for Noise

The noise may originate in the following processes:

- The image formation process
- The transmission process
- Combination of these two.[2]

1.4.3 Older Techniques for Denoising

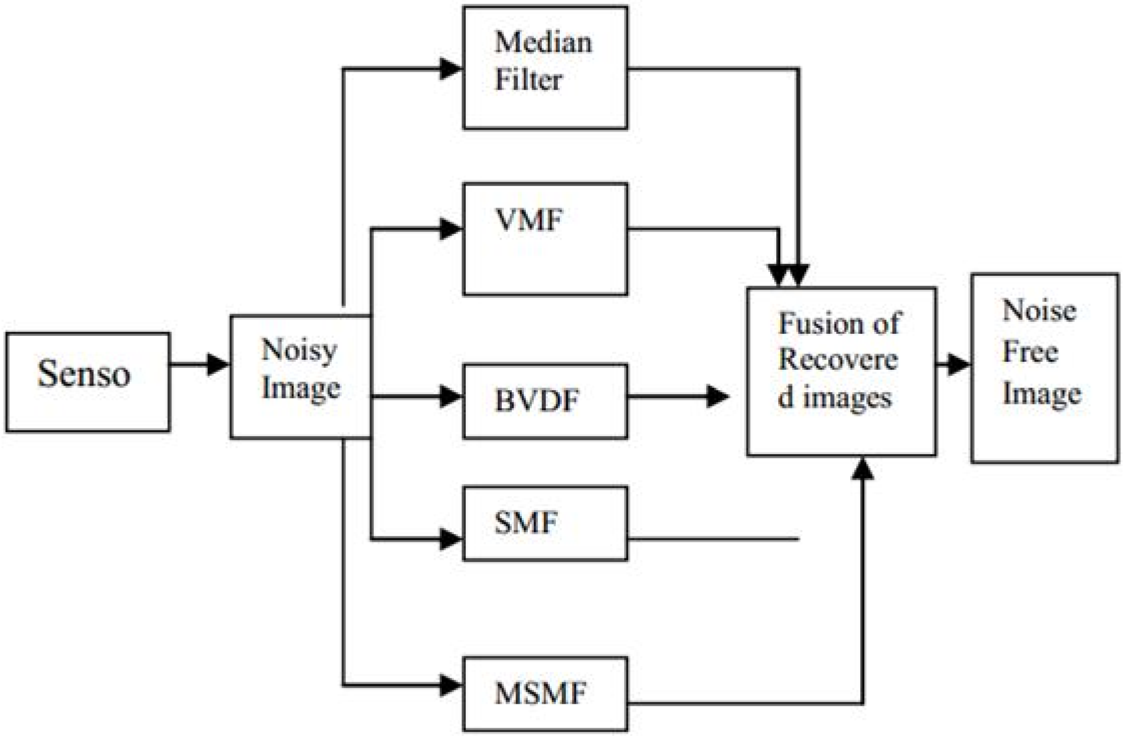


Figure 1.2 Block Digram of image fusion technique

Filters such as Arithmetic mean filter , Geometric mean filter , Median filter , Vector median filter , Basic Vector directional filter , Spatial median filter , Modified spatial median filter etc. are used over the degraded image their results are obtained and fused to get the recovered image.[3]

The fault with such systems is that not all filters are required for all kinds of noises because filters like AMF can alter the image up to a great extent if not required. Moreover it's a waste of time and resource when we use all the filters instead of using the only one we need.

Chapter 2: Types of Noises and Filters

This chapter deals with the basic and most common types of noise that hamper satellite imagery and the filters which we can use to remove different types of noises that degrade an image.

2.1 Noise:

Three basic types of noises that degrade an image are:

- Impulse noise
- Gaussian noise
- Speckle noise

2.1.1 Impulse Noise:

Impulse noise has the property of either leaving a pixel unmodified with probability 1 -p or replacing it altogether with a probability p. The probability density function of impulse noise is given by:

$$P(z)= \begin{cases} P_a & \text{for } z=a \\ P_b & \text{for } z=b \\ 0 & \text{otherwise} \end{cases} \tag{2.1}$$

No matter what pixel depth is used, the binary representations assume that 0 is black and the maximum value (255 at 8 bpp, 65,535 at 16 bpp, etc.) is white, if not otherwise noted.If b>a, gray level b appears as a light dot in the image. Conversely, level a appears like a dark dot. If either Pa or Pb is zero its called unipolar image.If in any case, the probability is zero and especially if they are approximately equal, impulse noise values resemble salt and pepper granules randomly distributed over the image. For this reason, bipolar noise or impulse noise is also called salt and pepper noise.

The source of this noise is usually the result of an error in transmission or atmospheric or man-made disturbance.

Figure 2.1 Original image

Figure 2.2 Original image was introduced with impulse noise

2.1.2 Gaussian Noise:

Gaussian noise is statistical noise that has a probability density function of the normal distribution (also known as Gaussian distribution). In other words, the values that the noise can take on are Gaussian-distributed. It is most commonly used as additive white noise to yield additive white Gaussian noise (AWGN). Because of its mathematical tractability in both the spatial and frequency domains, Gaussian noise models are used frequently in practice.

The probability density function of Gaussian random variable z is given by:

$$P(z) = (1 / \sqrt{2}\,\sigma)\,[e \wedge - \{ (z - \mu) \wedge 2 \} / 2\,\sigma \wedge 2] \quad (2.2)$$

Where z represents gray level, μ is the mean of average value of z and σ is its standard deviation. The standard deviation σ^2 is called the variance of z.[4]

Figure2.3 Original image was introduced with gaussian noise

2.1.3 Speckle noise

Speckle noise is a granular noise that inherently exists in and degrades the quality of images. Speckle noise is a multiplicative noise, i.e. it is in direct proportion to the local grey level in any area. The signal and the noise are statistically independent of each other.

Figure 2.4 Original image was introduced with speckle noise

2.2 Filters

Filters that can help in restoring a degraded image are:

- Arithmetic mean filter(AMF)
- Geometric mean filter(GMF)
- Median filter(MF)

2.2.1 Arithmetic Mean Filter:

This is the simplest of the mean filters. Let Sxy represent the set of coordinates in a rectangular image window of size m × n, centred at point (x, y).The arithmetic mean filtering process computes the average value of the corrupted image g(x, y) in the area defined by Sxy. The value of the restored image at any point (x, y) is simply the arithmetic mean computed using the pixels in the region defined by S.

$$f(x , y) = (1/m *n) \sum_{(s , t \in Sxy)} g(s , t) \qquad (2.3)$$

2.2.2 Geometric Mean Filter:

Here, each restored pixel is given by the product of the pixels in the image window, raised to the power 1/m*n. A geometric mean filter achieves smoothing comparable to the arithmetic mean filter, but it tends to lose less image detail in the process.

$$f(x , y) = [\prod_{(s , t) \in Sxy} g(s , t)]\text{^ } 1/m*n \qquad (2.4)$$

2.2.3Median Filter:

It is the best known order-statistics filter. As its name implies it replaces the value of a pixel by the median of the gray levels in the neighbourhood of that pixel.

$$f(x , y) = \underset{(s , t) \in Sxy}{\text{median}} \{ g (s , t) \} \qquad (2.5)$$

2.3 PSNR (Peak Signal to Noise Ratio)

Peak Signal to Noise Ratio or PSNR is calculated to compare signals. It is the ratio in between the peak signal of the power and after it has been corrupted with noise.

$$MSE = 1/m*n \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) – K(i,j)]^2 \qquad (2.6)$$

$$PSNR = 20 \log_{10} (Max_I^2 / MSE) \qquad [5](2.7)$$

Where MSE= Mean Squared Error
Max_I = Maximum Intensity
PSNR = Peak Signal to Noise Ratio

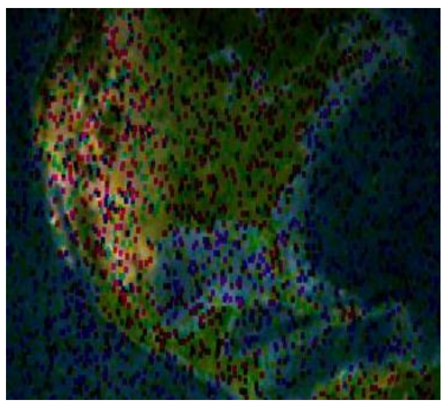
Chapter 3: Results and Discussion

This chapter deals with image with different noises and the result after application of filter.

3.1 Application of filters on Impulse noise:

(a)Original image

(b)Image with Impulse noise



(c)After application of AMF filter (d)After application of GMF filter (e)After application of MF filter

Figure3.1.1An image was taken and impulse noise was introduced to it. After that Arithmetic Mean filter, Geometric Mean filter and Median Filter was applied. Above are the results.

Table-3.1 More satellite images were taken, impulse noise was introduced and after that AMF, GMF and Median filters were introduced. This table represents images and there corresponding PSNR values after application of median filter, geometric mean filter and arithmetic mean filter.

Image no.	median filter	geometric mean filter	arithmetic mean filter
1	30.2772	13.7993	24.9466
2	40.9191	19.7404	25.3128
3	28.7402	16.7894	23.3614
4	36.8354	16.5045	25.5587
5	33.911	18.3854	24.8394

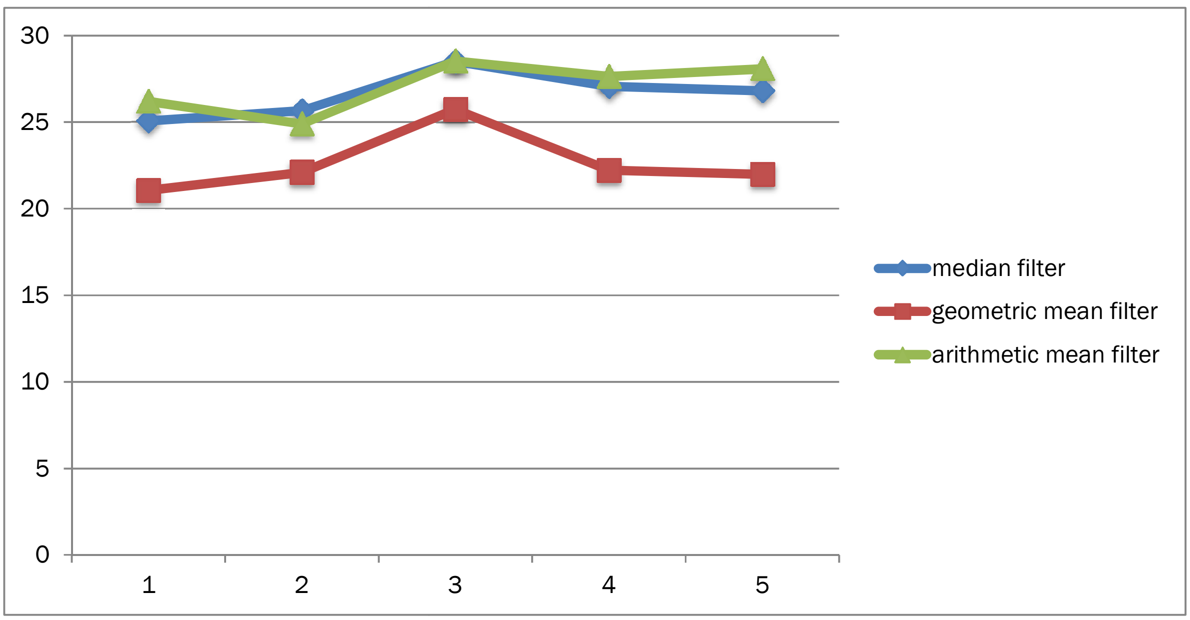
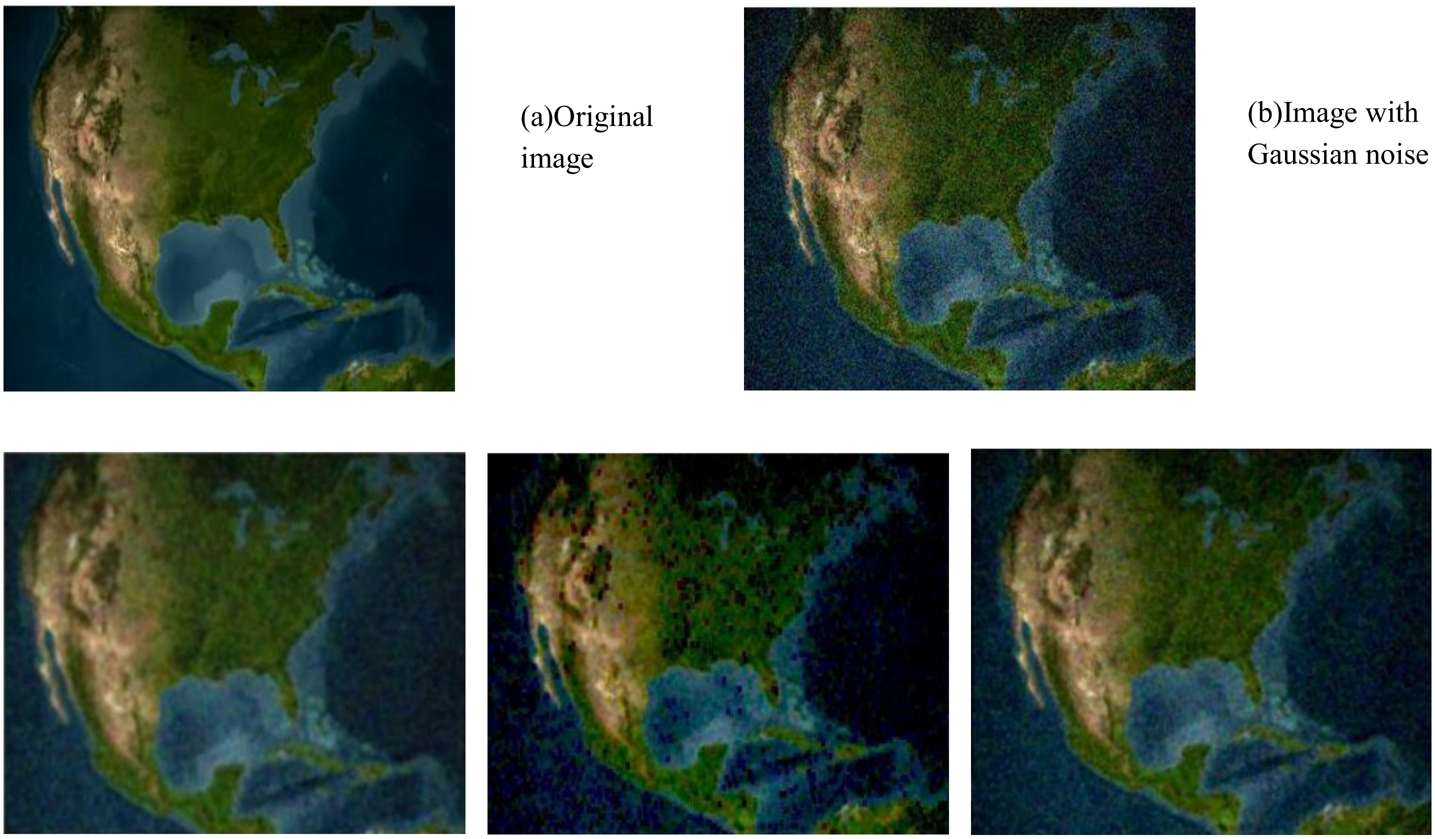


Figure-3.1.2 PSNR ratios were calculated and were plotted. X-axis represents various images (digits are their serial no.s) and Y-axis represents PSNR values after thhe application of impulse noise.

3.2 Application of filters on Gaussian noise:



(a)Original image

(b)Image with Gaussian noise

(c)After application of AMF filter

(d)After application of GMF filter

(e)After application of MF filter

Figure3.2.1 An image was taken and gaussian noise was introduced to it. After that Arithmetic Mean filter, Geometric Mean filter and Median Filter was applied. Above are the results.

Table-3.2 More satellite images were taken, gaussian noise was introduced and after that AMF, GMF and Median filters were introduced. This table represents images and there corresponding PSNR values after application of median filter, geometric mean filter and arithmetic mean filter.

Image no.	median filter	geometric mean filter	arithmetic mean filter
1	25.06722	21.04749	26.20587
2	25.65641	22.09977	24.89883
3	28.50473	25.72949	28.52803
4	27.06488	22.21866	27.63693
5	26.81097	21.98049	28.08017

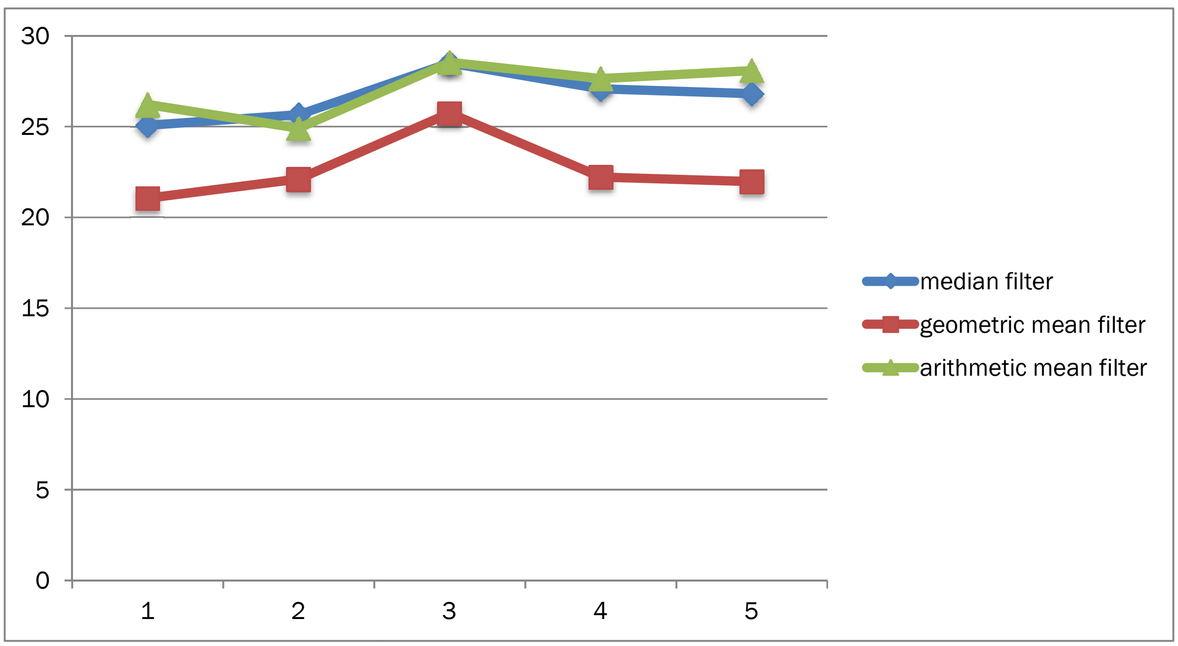


Figure-3.2.2 PSNR ratios were calculated and were plotted. X-axis represents various images (digits are their serial no.s) and Y-axis represents PSNR values after the application of gaussian noise.

3.2 Application of filters on Speckle noise:

(a)Original image

(b)Image with speckle noise

(c)After application of AMF filter

(d)After application of GMF filter

(e)After application of MF filter

Figure3.3.1 An image was taken and speckle noise was introduced to it. After that Arithmetic Mean filter, Geometric Mean filter and Median Filter was applied. Above are the results.

Table-3.3 More satellite images were taken, speckle noise was introduced and after that AMF, GMF and Median filters were introduced. This table represents images and there corresponding PSNR values after application of median filter, geometric mean filter and arithmetic mean filter.

Image no.	median filter	geometric mean filter	arithmetic mean filter
1	25.53508	24.3425	27.08831
2	25.82147	25.02526	26.29111
3	31.28886	33.51795	34.32375
4	28.12054	25.99344	28.37479
5	23.935	22.21886	24.0252

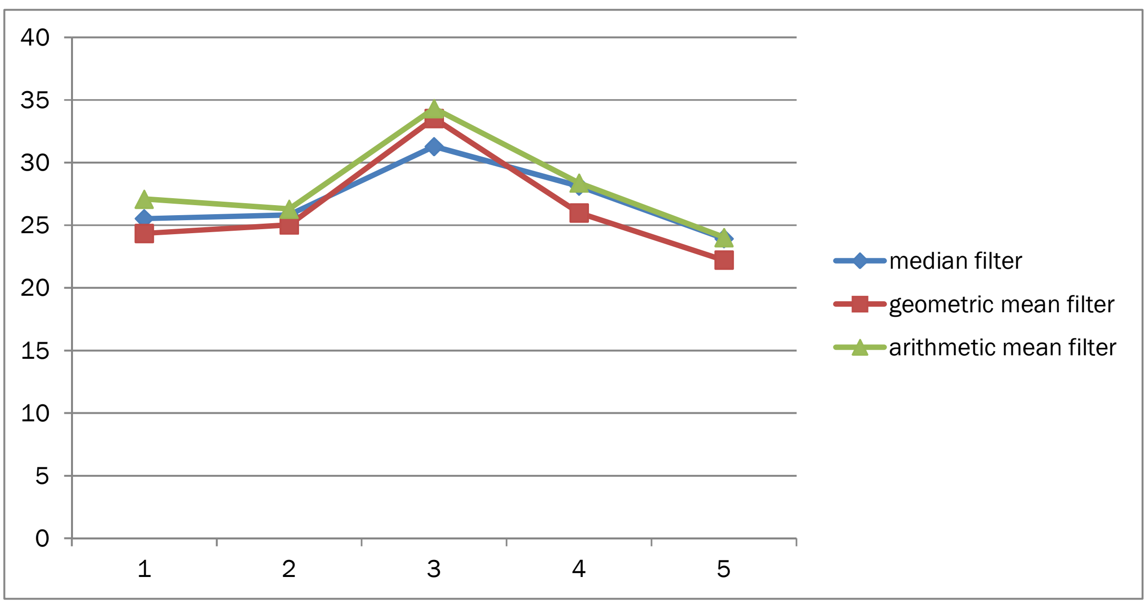


Figure3.3.2 PSNR ratios were calculated and were plotted. X-axis represents various images (digits are their serial no.s) and Y-axis represents PSNR values after the application of speckle noise.

Chapter 4: Conclusion

The satellite images which have been have been affected by Impulse noise can be rectified using median filter. Similarly the satellite images which have been have been affected by Gaussian noise can be rectified using Arithmetic mean filter.Moreover the satellite images which have been have been affected by Speckle noise can be rectified using Gaussian filter.

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