Image De-noising Using Various Filtering Techniques

[1]Monika Sharma, [2]Pooja Sharma, [3]Risheek Kumar
[1] Student, [2] Student, [3] Assistant Professor
[1]Electronics and Communication Department,
[1]Bhagwan Parshuram Institute of Technology, New Delhi, India

***Abstract:** Image processing is a method to perform various operations on an image, in order to achieve an enhanced quality of the image or to extract some useful information from it. It is a type of signal processing in which input is an image and output maybe image or characteristics or features associated with that image. Noise is an unwanted or distorted signal that may corrupt the quality or originality of the image. Image de-noising is the first step in analyzing the data to restore the quality of the image. Noise reduction is the challenging issue for the researchers as it may distort the actual image. This paper discusses common noise types found in digital images (i.e. Gaussian Noise, Poisson Noise, Speckle Noise and Salt & Pepper Noise) and their filtering techniques using various filters (Linear Filter, Average Filter, Median filter and Wiener Filter). Simulation results of mentioned filters are compared on the basis of SNR, PSNR and MSE.*

***Index Terms** - Image Processing, Image De-noising, SNR, PSNR, MSE.*

I. INTRODUCTION

Noise represents unwanted information which deteriorates image quality. Noise is a random variation of image intensity and visible as grains in the image [1]. Noise means, pixels within the picture present different intensity values rather than correct pixel values. Noise originates from the physical nature of detection processes and has many specific forms and causes, Noise is defined as a process (n) which affects the acquired image (f) and is not part of the scene (initial signal-s), and so the noise model can be written as

$$F(i, j) = s(i, j) + n(i, j).$$

Digital image noise may come from various sources. The acquisition process for digital images converts optical signals into electrical signals and then into digital signals and is one processes by which the noise is introduced in digital images. Each step in the conversion process experiences fluctuations, caused by natural phenomena, and each of these steps adds a random value to the resulting intensity of a given pixel.

Sources of Noise: Digital noise is generally caused by insufficient light levels at the site location [2]. It may also occur when the imaging sensors come under the effect of environmental conditions at the time of image acquisition. Another cause is heat, the image sensor heats up causing photons to get separated from the photo sites and taint other photo sites. A very slow shutter speed allows the noise to enter. Presence of dust particles on the scanner screen and the presence of inference in the transmission channel can also corrupt the image. Image noise can be classified as:

- Amplifier noise (Gaussian noise)
- Shot noise (Poisson noise)
- Multiplicative noise (Speckle noise)
- Impulse noise (Salt & pepper noise)

II. TYPES OF NOISE

II.A GAUSSIAN NOISE

Gaussian noise is evenly distributed over signal. This means that each pixel in the noisy image is the sum of the true pixel value and a random Gaussian distributed noise value [3]. The noise is independent of intensity of pixel value at each point. A special case is white Gaussian noise, in which the values at any pair of times are identically distributed and statistically independent. White noise draws its name from white light. Principal sources of Gaussian noise in digital images arise during acquisition, for example sensor noise caused by poor illumination or high temperature or transmission.

Gaussian Noise:

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

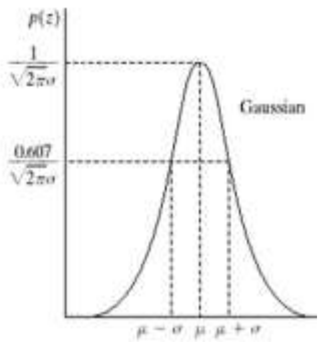


Fig. (i) Variation of Gaussian noise with μ

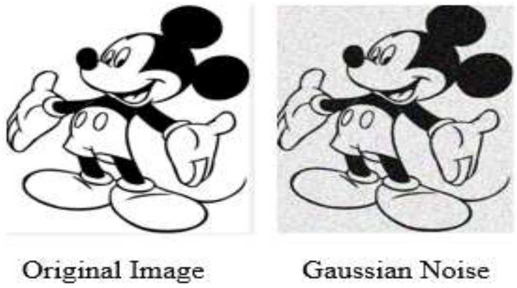
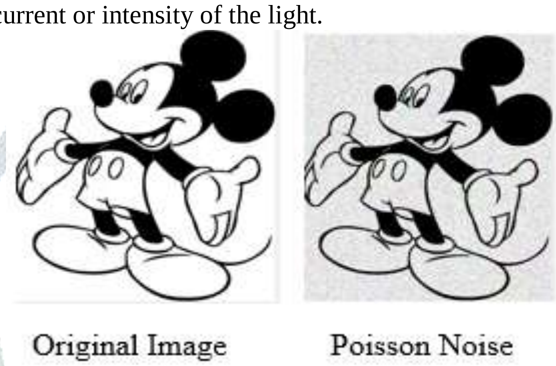


Fig. (ii) Comparison of real image and image with Gaussian noise

II.B POISSON NOISE

Poisson or shot photon noise is the noise that is caused when number of photons sensed by the senor is not sufficient to provide detectable statistical information [3]. Shot noise exists because a phenomenon such as light and electric current consists of the movement of discrete packets. Shot noise may be dominated when the finite number of particles that carry energy is sufficiently small so that uncertainties due to the Poisson distribution, which describe the occurrence of independent random events, are of significance. Magnitude of this noise increase with the average magnitude of the current or intensity of the light.



Fig(iii) Comparison of real image and image with Poisson noise

II.C SPECKLE NOISE

Speckle noise is multiplicative noise unlike the Gaussian and salt pepper noise [3]. This noise can be modeled by random vale multiplications with pixel values of the image and can be expressed as: -

$$P = I + n * I$$

Where P is the speckle noise distribution image, I is the input image and n is the uniform noise image by mean o and variance v. Speckle noise is commonly observed in radar sensing system, although it may appear in any type of remotely sensed image utilizing coherent radiation. Like the light from a laser, the waves emitted by active sensors travel in phase and interact minimally on their way to the target area. Reducing the effect of speckle noise permits both better discrimination of scene targets and easier automatic image segmentation.

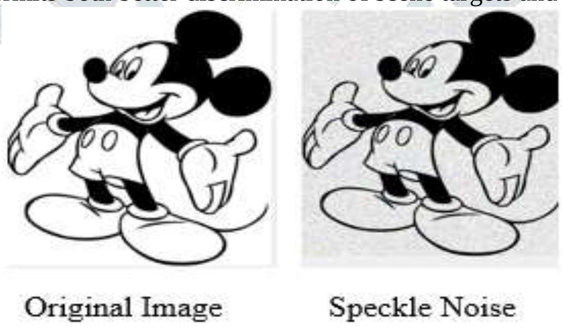


Fig. (iv) Comparison of real image and image with Speckle noise

II.D 2.4. SALT & PEPPER NOISE

Salt and pepper noise is an impulse type of noise. It is actually the intensity spikes. This type of noise is coming due to errors in data transmission. This noise occurs in the image because of sharp and sudden changes of image signal. For images corrupted by salt and pepper noise the noisy pixels can take only the maximum and the minimum values in the dynamic range. It is found that an 8- bit image, the typical value for pepper noise is 0 and for salt noise it is 255. The salt and pepper noise is generally caused by malfunctioning of pixel elements in the camera sensors, faulty memory locations or timing errors in the digitization process.

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

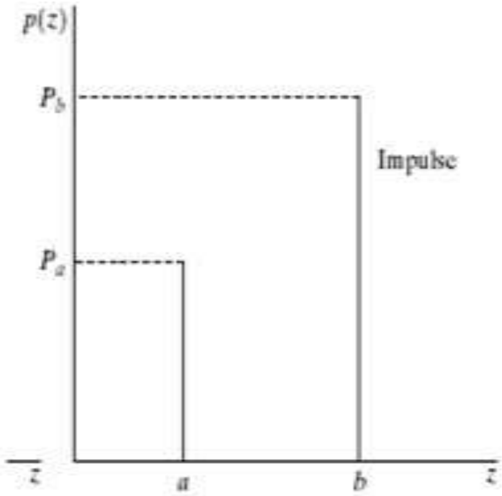


Fig. (v) p(z) for salt and pepper noise vs z

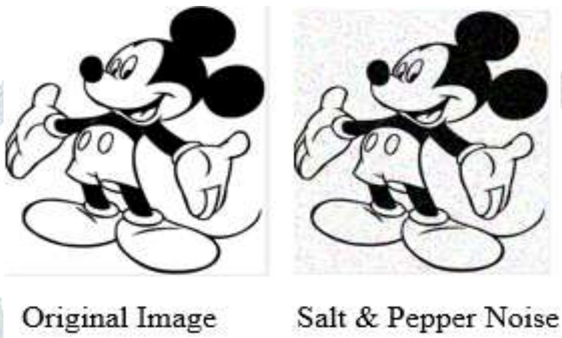


Fig. (vi) Comparison of real image and image with Salt and Pepper noise.

III. IMAGE QUALITY METRICS

III.A SIGNAL TO NOISE RATIO (SNR)

SNR compares the level of desired signal to the level of background noise. The higher the ratio, the less obtrusive the background noise is

$$SNR = {P_{signal}}/{P_{noise}}$$

III.B PEAK SIGNAL TO NOISE RATIO (SNR)

The Peak Signal to Noise Ratio (PSNR) is the value of the noisy image with respect to that of the original image. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed or reconstructed image.

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

Here MAX_f is the maximum signal value that exists in our original image.

III.C MEAN SQUARE ERROR (MSE)

The MSE symbolizes your cumulative squared mistake relating to the compacted along with the unique image.

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

Where f represents the matrix data of our original image, g represents the matrix data of our degraded image, m represents the numbers of rows of pixels of the image and i represent the index of that row, n represents the number of columns of the pixels of the image and j represents the index of that column.

IV. IMAGE DE-NOISING TECHINIQUES

Image de-noising is the first step in image processing. To detect and then filter the image so that the data can be analyzed for further process. Image de-noising helps in noise reduction, interpolation and resampling. Image is filtered through various techniques that depend on the behavior and the type of the image [4]. It is a big challenge to remove the noise from the image while keeping the details of the image preserved. Various image de-noising methods are described below:

IV.A MEAN FILTER

Mean filter is a type of linear filter that computes average value of the corrupted image in a pre-decided area or mask. Basically, the mask is of 3x3. The window can be of any shape normally square. In the window center pixel intensity value is replaced by that average value. This process is repeated for all the pixel values in the image. This type of filter is appropriate for Averaging or Gaussian filters [4]. Changes in the value depend on the coefficient of the mask sum. If the coefficient of the mask sum is up to one, then the average brightness of the image is not changed. If the coefficient sum is zero, average brightness is lost and it returns a dark image.

Unfiltered Values		
8	4	7
2	1	9
5	3	6

Mean filtered		
*	*	*
*	5	*
*	*	*

Fig. (vii) Unfiltered and Mean Filtered Values.

In this centre value which is previously 1 in the unfiltered value is replaced by the mean of all nine value that is 5.

$$(8+4+7+2+1+9+5+3+6)/9 = 5$$

IV.B MEDIAN FILTER

Median filter is a type of non-linear filter. It uses to reduce the amount of intensity variation between one pixel and the other pixel. This technique is much similar to mean filter. In this filter, pixel value of image is replacing with the median value of neighborhood rather than mean values. Median filter provides the best result when impulse noise percentage is less than 0.1% [5].

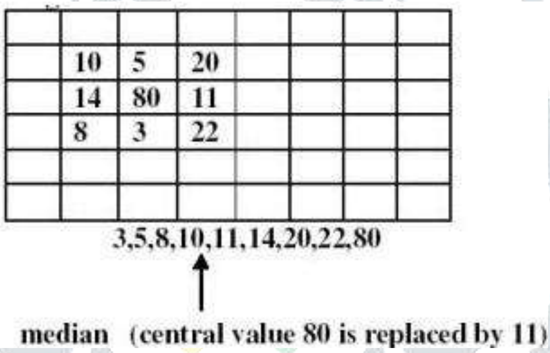


Fig. (viii) Median Filtered Values.

IV.C ADAPTIVE FILTER

This technique changes the behavior of the image. It is more selective than a comparable linear filter. It stores the edges and other high frequency parts of an image [4]. This technique uses wiener2 function that handles all the computations and applies filter to the input image. But wiener2 function takes more computational time than linear filtering.

V. RESULTS

The Original Image is Mickey Mouse image, adding four types of Noise (Gaussian noise, Poisson noise, Speckle noise and Salt & Pepper noise) and de-noised image using Mean filter, Median filter and Wiener filter and comparisons among them based on SNR, PSNR and MSE.

Fig. (ix) Original Image

V.A GUASSIAN NOISE

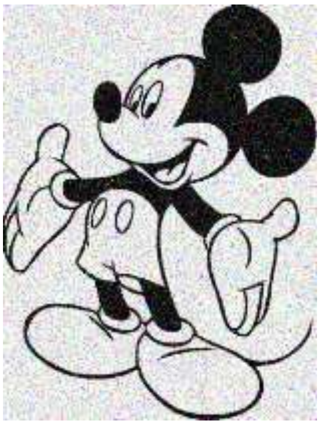


Fig. (x) Image with Gaussian Noise

Fig. (xi) When mean filter is used for Gaussian noise
PSNR: 11.7875
SNR: 9.6093
MSE: 4038.5261

Fig. (xii) When median filter is used for Gaussian noise
PSNR: 16.782
SNR: 15.2157
MSE: 1362.263

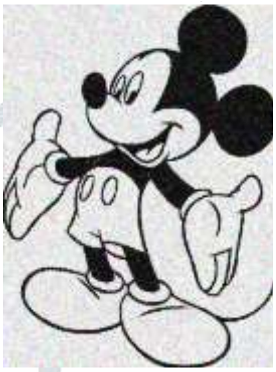


Fig. (xiii) When adaptive filter is used for Gaussian noise
PSNR: 19.0501
SNR: 17.0373
MSE: 809.2251

V.B POISSON NOISE

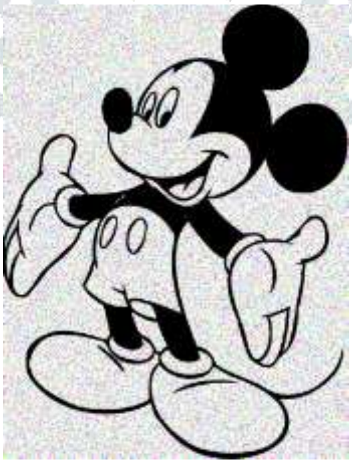


Fig. (xiv) Image with Poisson Noise

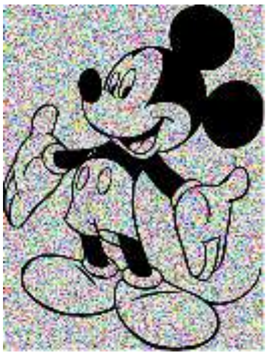


Fig. (xv) When mean filter is used for Poisson noise,
PSNR: 11.7043
SNR: 9.0761
MSE: 4391.891

Fig. (xvi) When median filter is used for Poisson noise,
PSNR: 18.1891
SNR: 16.4903
MSE: 986.6765

Fig. (xvii) When adaptive filter is used for Poisson noise,
PSNR: 19.8603
SNR: 17.7477
MSE: 671.5122

V.C SPECKLE NOISE

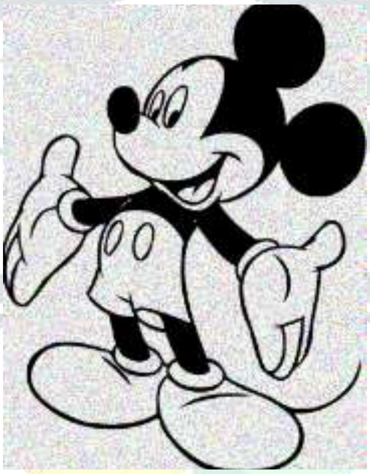


Fig. (xviii) Image with Speckle Noise

Fig. (xix) When mean filter is used for Speckle noise,
PSNR: 11.7200
SNR: 9.0958
MSE: 4316.0000

Fig. (xx) When median filter is used for Speckle noise,
PSNR: 18.2154
SNR: 16.5169
MSE: 980.704

Fig. (xxi) When adaptive filter is used for Speckle noise,
PSNR: 19.8829
SNR: 17.7730
MSE: 668.0216

V.C SALT AND PEPPER NOISE

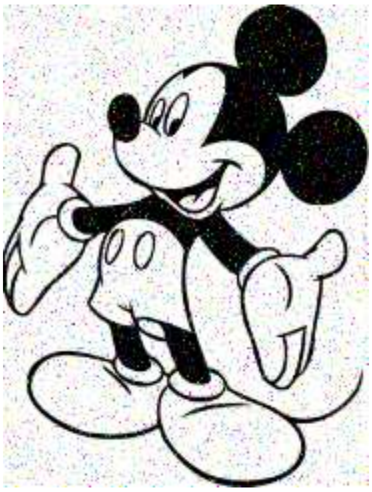


Fig. (xxii) Image with Salt and Pepper Noise

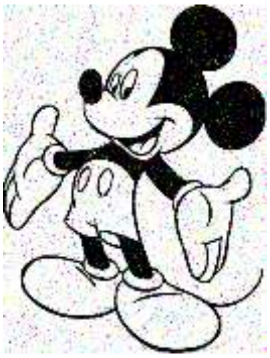


Fig. (xxiii) When mean filter is used for Salt & Pepper noise,
PSNR: 25.0273
SNR: 23.7709
MSE: 204.3378

Fig. (xxiv) When median filter is used for Salt & Pepper noise,
PSNR: 16.0159
SNR: 14.7747
MSE: 1627.3194

Fig. (xxv) When adaptive filter is used for Salt & Pepper noise,
PSNR: 24.8826
SNR: 23.4535
MSE: 211.2637

VI. CONCLUSION

We used the Mickey Mouse Image in "jpg" format ,adding four noise (Speckle, Gaussian ,Poisson and Salt & Pepper) in original image, de-noised all noisy images by all filters (Mean Filter, Median Filter and Wiener Filter) and conclude that:

a) The performance of the Wiener Filter after de-noising for all Speckle, Poisson and Gaussian noise is better than Mean filter and Median filter.

b) The performance of the Median filter after de-noising for all Salt & Pepper noise is better than Mean filter and Wiener filter.

VII. FUTURE SCOPE

As there are number of image de-noising techniques used but still there is lot to happen. Further studies can be done in this field to provide more effective methodologies. Techniques that are already using may not be able to find the optimum result thus further studies may find the techniques that provide optimum solution to the noise [5].

VIII. REFERENCES

[1] Rohit Verma and Jahid Ali: "A comparative study of various types of image noise and efficient noise removal techniques", International journal of advanced research in computer science and software engineering, volume 3, issue 10 October 2013.

[2] Monika Kohli, Harmeet Kaur: "Noise Removal in Image Processing using Median, Adaptive Median and Proposed Median Filter and Respective Image Quality Comparison", International journal of engineering technology, management and applied sciences, volume 3, issue November 2015.

[3] Sukhjinder Kaur: "Noise Types and Various Removal Techniques", International Journal of Advanced Research in Electronics and Communication Engineering, Volume 4, Issue 2, February 2015.

[4] Gursharan Kaur, Rakesh Kumar, Kamaljeet Kainth: "A Review Paper on Different Noise Types and Digital Image Processing", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 6, Issue 6, June 2016.

[5] Priyanka Kamboj et al.," Brief study of various noise model and filtering techniques", vol.4, No.4, pp.166-171, April 2013.