A Review Paper: Study of Various Types of Noises in Digital Images

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Abstract - *Noise in the images are common during its acquisition, processing, compression, transmission, and reproduction. These noises are of different types/kinds. It is very difficult to remove noises without the prior knowledge about these. Therefore review of different types of noises is essential in image denoising technique. In this paper, we present a complete and quantitative analysis of various types of noise available in digital images.*

Key words - *noise type, digital images, probability density functions*

I INTRODUCTION

Image is a powerful medium to convey visual information. Digital Image Processing involves the modification of digital data for improving the image qualities with the aid of computer. The processing helps in maximize the clarity, sharpness of image and details of features of interest towards extraction of information & further analysis. In digital image the noise may come from various sources. In the acquisition process the optical signal is converted in to Electrical signal and converts into digital signals and at the processing time by which the noise is introduced in digital image. Each step in the conversion process it experiences fluctuations caused by natural phenomena, and each of this steps adds a random value to the resulting intensity to a given pixel.

The principal sources of noise in digital images are:

1. Noise arise during the time of image acquisition or transmission.

2. Noise can be the result of the damage to the film, or be introduced by the scanner itself.

3. At the time of image acquisition the light level and sensor temperature are the major factors affecting the amount of noise in the resulting image.

4. The imaging senor may be affected by environmental conditions during image acquisition.

5. If the image is acquired directly in a digital format, the mechanism for gathering the data can introduce noise.

6. Electronic transmission of image data can introduce noise.

7. Interference in the transmission channel may also corrupt the image.

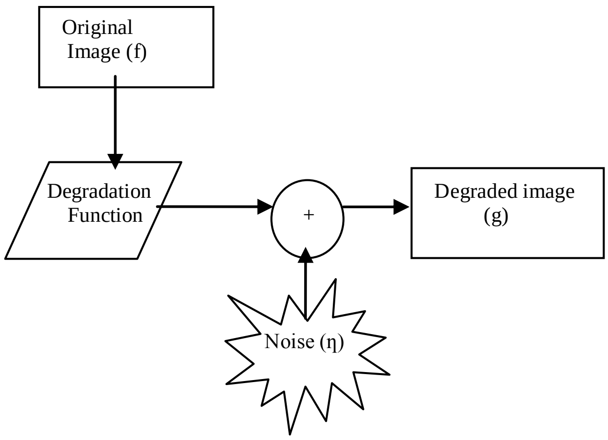
8. If dust particles are present on the scanner screen, they can also introduce noise in the image.

We can consider a noisy image to be modelled as follows:

$$g(x,y) = f(x,y) + \eta(x,y)$$

where f(x, y) is the original image pixel, η(x, y) is the noise term and g(x, y) is the resulting noisy pixel.

The degradation model is structured as follows:

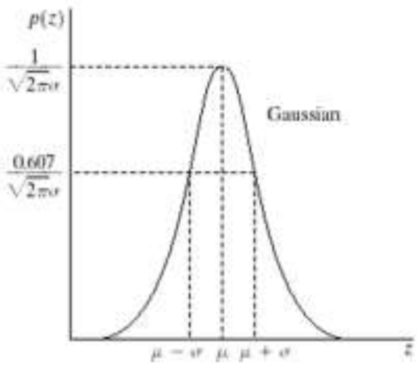


II VARIOUS TYPES OF NOISES IN IMAGES &THEIR MODELS

2.1 Gaussian Noise

Gaussian noise is one type of statistical noise. It is evenly distributed over the signal. The probability density function (PDF) of Gaussian noise is equal to that of the normal distribution and also known as Gaussian distribution. It is usually used as additive white noise to give additive white Gaussian noise (AWGN).

Then PDF of Gaussian noise is



Where z represents gray level, μ is the mean of average value of z and σ is its standard deviation.

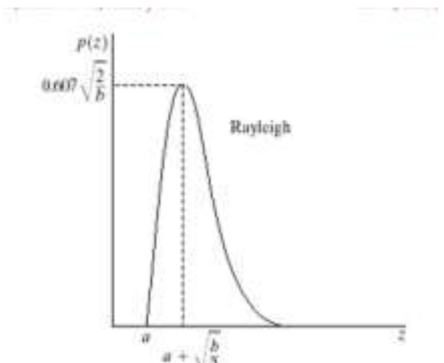
Principal sources of Gaussian noise in digital images arise during acquisition e.g. sensor noise caused by poor illumination and/or high temperature, and/or transmission.

2.2 Rayleigh Noise:

A Rayleigh noise distribution is often observed when the overall magnitude of a vector is related to its directional components that is where Rayleigh distribution naturally arises is when wind velocity is analyzed into its orthogonal two dimensional vector components.

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

The PDF of Rayleigh noise is



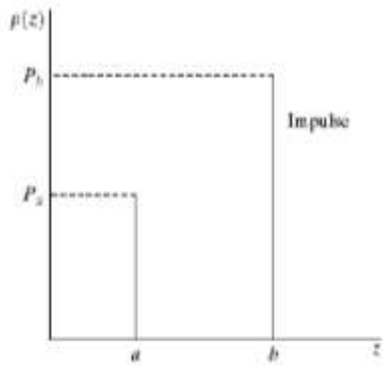
2.3 Salt and Pepper Noise

The salt-and-pepper noise are also called shot noise, impulse noise or spike noise that is usually caused by faulty memory locations , malfunctioning pixel elements in the camera sensors, or there can be timing errors in the process of digitization.

When an analog image signal is transmitted in a linear dispersive channel the image edges get blurred and the image signal gets contaminate with additive white Gaussian noise since no practical channel is noise free. If the channel is so poor that the noise variance is high enough to make the signal excurse to very high negative or positive value when the thresholding operation at the front end of the receiver will contribute saturated min and max value. As a result, the image contains some black and white spot. This type of noise is called salt and pepper noise. At the same time the image contain the dark is called pepper and the image contain the bright pixel is known as salt. Therefore the analog image signal is transmitted and the signal gets corrupted with Additive White Gaussian Noise and Salt and Pepper as well. Then there is an effect of mixed noise.

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

Then the PDF of salt and pepper noise is



2.4 Speckle Noise:

Speckle noise is granular noise that inherently exists in and degrades the quality of the active radar and Synthetic Aperture Radar (SAR) images. In some Biomedical applications like Ultrasonic Imaging and a few emergency applications like Synthetic Aperture Radar (SAR) imaging such noise is encountered. In the speckle noise, if the image pixel magnitude is high then the noise is also high. So speckle noise is dependant to the signal. The noise is multiplicative because initially a transmitting system transmits a signal to the object and the reflected signal is recorded. When the signal is transmitted, the signal may get contaminated with additive noise in the channel. Due to varying reflectance of the surface of the object, the reflected signal magnitude varies. So also the noise varies since the noise is also reflected by surface of the object. Noise magnitude is there for higher when the signal magnitude is higher so we say that the speckle noise is multiplicative in next area. But at the same time speckle is random, deterministic, interference pattern is an image formed with coherent radiation of a medium containing many sub resolution strategies.

Speckle noise is eliminated using adaptive and non-adaptive filters.

Let a digital image f(x,y), after being corrupted with multiplicative noise, be represented as P(x,y). Then, the noisy image P(x,y) is mathematically represented as

$$P(x,y) = f(x,y) + \eta(x,y) f(x,y)$$

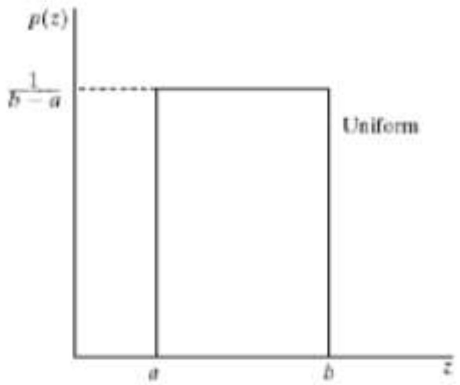
$$P(x,y) = [1 + \eta(x,y)] f(x,y)$$

Where η (t) is a random variable

2.5 Uniform Noise:

The uniform noise cause by quantizing the pixels of image to a number of distinct levels is known as quantization noise. It has approximately uniform distribution. In

the uniform noise the level of the gray values of the noise are uniformly distributed across a specified range. Uniform noise can be used to generate any different type of noise distribution. This noise is often used to degrade images for the evaluation of image restoration algorithms.



This noise provides the most neutral or unbiased noise

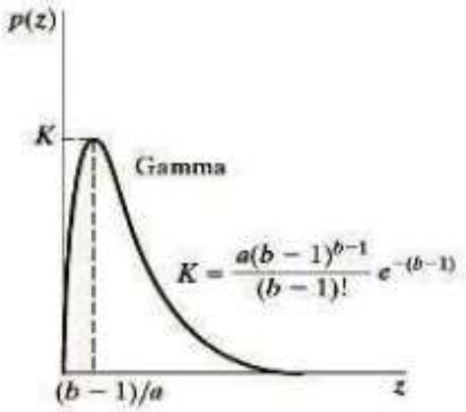
$$P(z) = \begin{cases} \frac{1}{b-a} & \text{if } a \le z \le b \\ 0 & \text{otherwise} \end{cases}$$

and their mean $\mu = \frac{a+b}{2}$ and

variance $\sigma^2 = \frac{(b-a)^2}{12}$

2.6. Gamma noise:

This type of noise can be obtained by the low-pass filtering of laser based images The PDF, mean and variance of Gamma Noise is given below:



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

The mean and variance of this density are given by

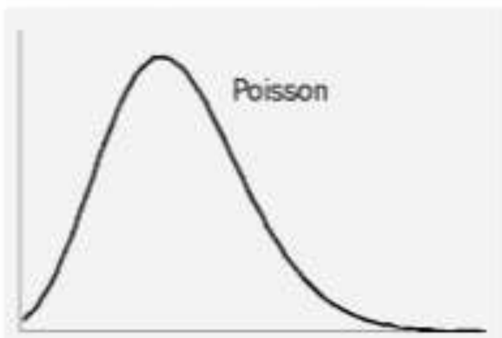
$$\mu = b/a$$

$$\sigma^2 = b/a^2$$

2.7 Poisson Noise

The appearance of this noise is seen due to the statistical nature of electromagnetic waves such as x-rays, visible lights and gamma rays. The x-ray and gamma ray sources emitted number of photons per unit time. These rays are injected in patient's body from its source, in medical x rays and gamma rays imaging systems. These sources are having random fluctuation of photons. Result gathered image has spatial and temporal randomness. This noise is also called as quantum (photon) noise or shot noise. This noise obeys the Poisson distribution and is given as

$$P(f_{(pi)}) = k = \frac{\lambda^k\ i^{e^{-\lambda}}}{k!}$$

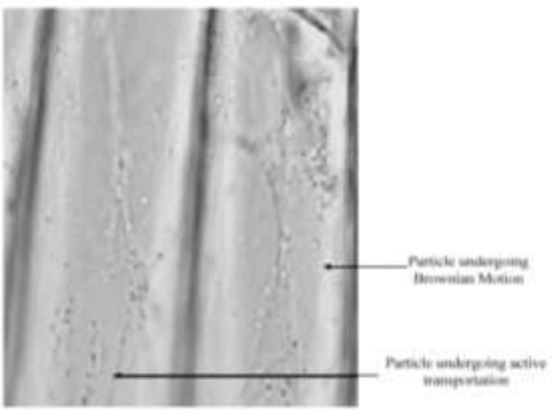


2.8 Brownian Noise (Fractal Noise) s

Colored noise has many names such as Brownian noise or pink noise or flicker noise or 1/f noise. In Brownian noise, power spectral density is proportional to square of frequency over an octave i.e., its power falls on ¼ th part (6 dB per octave). Brownian noise caused by Brownian motion. Brownian motion seen due to the random movement of suspended particles in fluid. Brownian noise can also be generated from white noise.

However this noise follows non stationary stochastic process. This process follows normal distribution. Statistically fractional Brownian noise is referred to as fractal noise. Fractal noise is caused by natural process. It is different from Gaussian process.

Although power spectrum of fractal noise, decaying continuously due to increase in frequency. Fractal noise is almost singular everywhere. A fractional Brownian motion is mathematically represents as a zero mean Gaussian process (B_H)



$B_H(0) = 0$

and expected value of fractional Brownian motion is

$$E\{|B_H(t) - B_H(t-\Delta)|^2\} = \sigma^2 \ |\Delta|^{2H}$$

III CONCLUSION

During image acquisition and transmission, noise is added to a lesser or greater extent affects the image . This is characterised by noise model. So study of noise model is very important part in image processing. Without having the knowledge about these models it is nearly impossible to remove the noise from the image and perform denoising actions.

Hence, here we have reviewed and presented various noise models available in digital images. Noise models also designed by probability density function using mean, variance and mainly gray levels in digital images.

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