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A REVIEW ON: NOISE MODEL IN DIGITAL IMAGE PROCESSING

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ABSTRACT

Image play a very important role in every aspect of life and it play a vital role in the area of research of digital image processing. So production of noise free image is very much essential in the field medical science, astronomy, film industry and in many more area. Noise in an image usually appears during image acquisition, coding, transmission and processing step. Without prior knowledge of Noise, it is very much difficult to remove it from a digital image. The noise destroys the original image quality by changing the true pixel value. So for reduction of noise from an original image it is very much essential to distinguish the type of noise, its effect in an image and its reduction technique. So this paper gives an over view of various type of noise and its impact in an image.

KEYWORDS: Noise model, pixel, Probability density function, Digital Image, power spectral density.

INTRODUCTION

Since last decades research are involved in the field of noise detection and reduction from a digital image. Because noise is an important factor of image processing which degrade the original image quality and affect the appearance of images by hiding the important details of an image. So it is very important to detect the type of noise, its characteristic and its impact in an image.

Noise is an error or unwanted signal or information which destroys image quality. It is the random variation in image quality that produces different intensity value of pixel instead of true pixel value. Mathematically Noise is defined [1] as a process (n) which effect images (F) and is not part of the scene. Usually the additive noise model, the process can be defined as

$$F(i, j) = S(i, j) + n(i, j) \quad (1)$$

In Digital Image noise may come from various sources. The acquisition process for digital image converts optical signal into electrical signal and then into digital signal.

Noise in an image arises due to the following reason:

There are various sources through which an image can be degraded

- Motion: Relative motion in between the capturing device and the object being captured is a major cause in destruction of image quality.
- Defocusing: If there is a fault in the capturing device and it fails to sets its focus perfectly then because of defocusing image quality is degrades.
- Atmospheric Turbulence: The atmospheric condition plays an important role in image quality. The atmospheric conditions such as temperature, pressure, humidity, weather condition etc. are also responsible for causing unclear vision of an image.
- Quality of lances: The quality of lances in a camera plays a vital role for capturing an image. The human eye is considers as a best lances in the world. Perhaps various cameras which to be used for taking images must be good in qualities.
- If some noise reduction technique is used again and again in a single image it decreases the quality of non-noisy image and produces degradation in image quality.

So for reduction of noise from a noisy image a prior knowledge of the type of noise and

it's character is very much essential. So here a brief representation of noise model is given below.

NOISE MODEL

Noise is an unwanted signal or information which destroys image quality and causes degradation in image quality[3]. A digital image is corrupted by noise during image acquisition or during image transmission. An image is affected by variety of reason such as environmental condition during image acquisition or quality of sensing element themselves

There are different types of noise in image which can destroy image quality. Those noises are

Uniform noise:

When the grey level value of the noise is distributed uniformly in an image in a specific range then this type of noise is called a uniform noise [4].

The probability distribution of uniform noise is

$$Pu(z) = \begin{cases} 1/(b-a) & if\ a \le z \le b \\ 0 & otherwise \end{cases} \quad (2)$$

Mean= a+b/2

Variance= $(b-a)^2/12$

Histogram of Uniform Noise

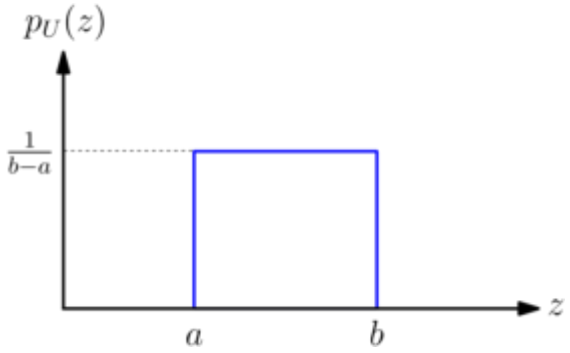


Fig-1: Uniform noise

Gaussian noise/Amplifier noise:

It is a statistical noise that has a probability density function (PDF) of the normal distribution also called as Gaussian distribution [5]. In this noise each pixel in the noisy image is the sum of the true value and a random Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point.

The PDF of Gaussian random variable is given by

$$F(g) = 1/\sqrt{2\pi\sigma^2}\quad e^{-(g-m)^2/2\sigma^2} \quad (3)$$

F (g) = Gaussian distribution noise in image

σ = Standard deviation

m = mean value

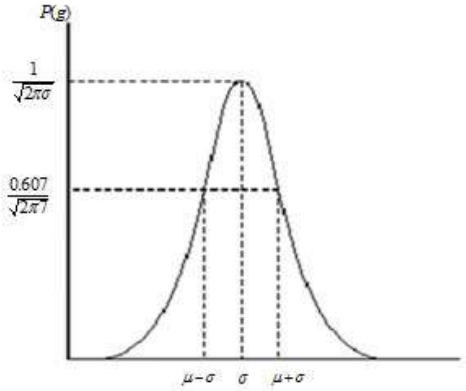


Fig-2: Bell Shaped Curve for Gaussian distribution

Salt and pepper noise/Impulse noise:
The Impulse noise is also called salt and pepper noise [6]. Black and White dotes appears in the image .As a result it is called as salt-and-pepper noise. Image having salt and pepper noise will have dark pixel in bright area that contain the extremely low value 0 and bright pixel in dark areas that contain the extremely high value 1. The noise arises in the image because of sharp and sudden change in image signal.

For 8 bit image, the typical value for pepper noise is 0 and 255 for salt noise.
The PDF of impulse noise is given by

$$P(z)=\begin{cases} p_a & for\ z=a \\ p_b & for\ z=b \\ 0 & otherwise \end{cases} \quad (4)$$

If b>a, intensity 'b' will appear as light dot in the image. Otherwise intensity 'a' appears like a dark dot.

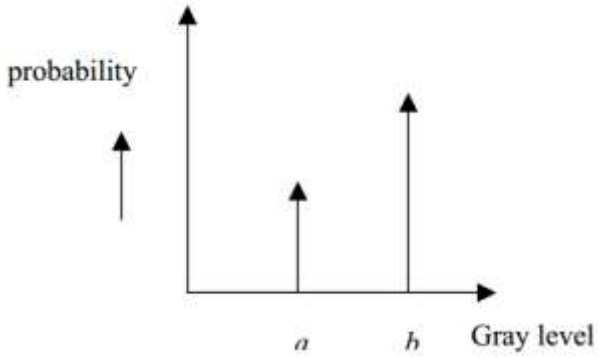


Fig- 3: Salt and Pepper Noise

Poission Noise/photon noise:
Poisson noise [7] is appears when the number of photon sensed by the sensor is not sufficient to provide detectable statistical information[3]. This type of noise is formed due to the electromagnetic wave such as x-ray, visible light and gamma ray. The probability density function of photon noise is

$$P(P/\rho, T)=(\rho^T)^P e^{-\rho T}/P! \quad (5)$$

Where ρ is the rate of intensity parameter measured in photon per T second

Rayleigh noise:

Radar range and velocity images typically contain noise that can be modelled by the Rayleigh distribution [8]. The probability density function of Rayleigh noise is

$$P(z)=\begin{cases} 2/b(z-a)e^{-\frac{(z-a)^2}{b}} & for\ z\geq a \\ 0 & for\ z<a \end{cases} \quad (6)$$

Mean =a+$\sqrt{\pi b/4}$

Variance σ^2=b (4-π)/4

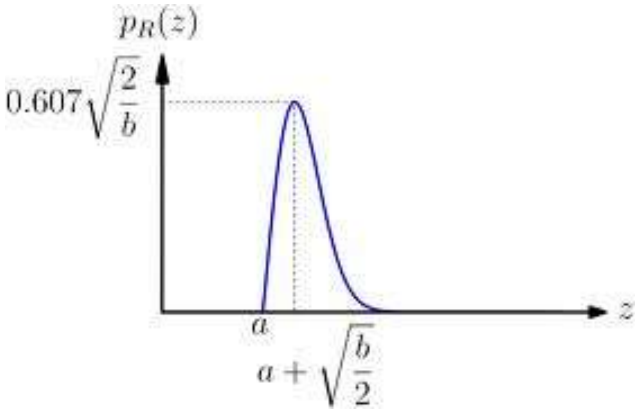


Fig-4:Rayleigh noise

Speckle noise:

This noise [9] can be modelled by random value multiplications with pixel values of the image and can be expressed as

$$J = I + n*I \quad (7)$$

Where, J is the speckle noise distribution image, I is the input image and *n* is the uniform noise image by mean *o* and variance *v*. This noise deteriorates the quality of images. This noise is originated because of coherent processing of back scattered signals from multiple distributed points.

Fig-5: Image of Speckle noise

Gamma noise:

Gamma noise is generally seen in the laser based image. It obeys the Gamma distribution [8,10]. The probability distribution function of Gamma noise is

$$P(g) = \begin{cases} a^b g^{b-1} e^{-ag} \Big/ (b-1)!, & for\ g \geq 0 \\ 0, & for\ g < 0 \end{cases} \quad (8)$$

Where the parameter a $>$ 0, b is a positive integer and "!" indicate the factorial.

Mean $\bar{z} = \frac{b}{a}$

Variance $\sigma^2 = \frac{b}{a^2}$

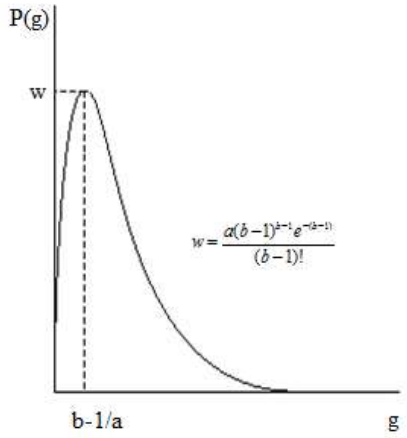


Fig-6: Gamma noise

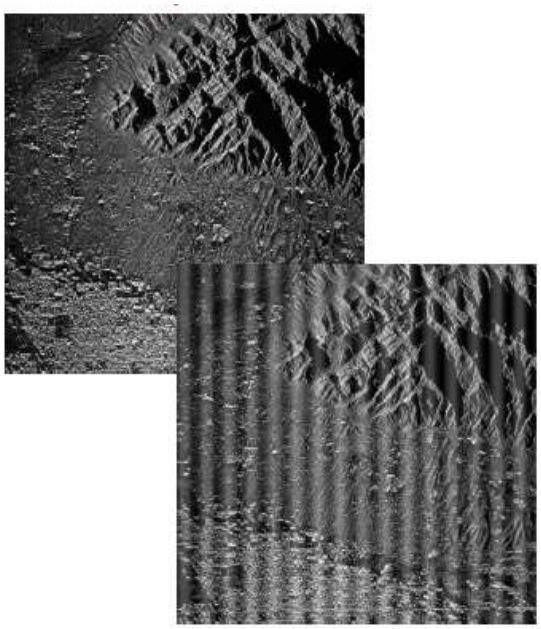
Periodic noise:

This noise is generated from electronics interference, especially in power signal during image acquisition. In a video stream the periodic noise is typically caused by the presence of electrical or electromechanical interference during video acquisition or transmission. This type of noise is most efficiently reduced with frequency domain filtering, which isolates the frequency occupied by the noise and supress them using band-reject filter.

Structural noise:

Structural noise may be periodic, stationary or nonstationary, aperiodic, detector striping and detector banding in nature. The periodic Structural noise commonly causes due to interface between electronic components. The structural noise having periodic, stationary in nature have fixed amplitude, frequency and phase.

Original image



Noisy Image

Fig-7:Structural noise having periodic, stationary in nature

The structural noise having periodic, nonstationary in nature have vary in amplitude, frequency and phase [11]. Structural aperodic noise generally created in JPEG noise.

Fig-8:Structural noise having periodic, non-stationary in nature

White noise:
In signal processing, white noise is a random signal with a constant power spectral density. The white noise is so named because it's analogous to white light. In particular each sample has a normal distribution with zero mean, then the signal is said to be Gaussian white noise. In a sample a white noise signal may be sequential in time. In digital image processing, the pixels of a white image are typically arranged in a rectangle grid [12].

Brownian noise:
Brownian noise is given after the name of botanist Robert Brown who discovered Brownian motion in the 1800s. Brown noise has a spectral density that is inversely proportional to its square of frequency [13]. In the other words its power significantly decreases as its frequency increases. As a result brown noise has a lot more energy at low frequency as compare to its higher frequency. Brownian motion is causes due to the random movement of suspended particles in fluid [14].

CONCLUSION

Noise is an important part of image processing which degrade the original image quality. Noise appears automatically in an image during image acquisition and transmission. So before going to the field of digital image processing it is very much essential to know the various types of noise and its impact in an image.

In this paper we discussed different type of noise and its impact in the digital image during image acquisition and transmission. Here light is also through on the cause of noise and there measure source.

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