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A review on: Different type of noise model in digital image processing

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Abstract--**The image plays an important role in the field of research in digital image processing. Digital image processing means processing digital image by use of computer through algorithm. Noise is a variation of brightness that may destroy part of an image. The unwanted signal of the noise can destroy image quality by changing the pixel value. Generally, Noise can always be seen during digital image processing, image acquisition, coding, transmission, and processing steps. Noise-free image is for various fields like Medical science, Astronomy, film industry, agriculture science, sports, machine vision, pattern recognition, and video processing in many more fields. To remove noise from the digital image, it is very hard without prior knowledge of noise. Distinguish the type of noise is very important for the reduction of noise from an original image. Types of noise effect in an image and its reduction technique. Several types of noise models are described in the review paper.**

I. INTRODUCTION

Nowadays Digital image play is a very important role. Digital image is known an image or picture which represented digitally in a groups of combinations bits or specifically called pixels. [1]. The digital image which represents a factual image of a group of number which is manipulated and stirred by a computer system for the purpose of converting the whole image into numbers, the image is partitioned into tiny areas which are known as pixels [2] [3]. Every single pixel contained in an image and device documents a group of numbers which brief some attribute of this pixel, the light intensity(color and its brightness)

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The noise which is an unwanted signal affects an image. Removal of noise from an image is called de-noising [4] [5]. while the imaging device carrying out its function, there can occurring possibility of variation of brightness or unwanted signal which is called noise. Before starting the solution of image noise, we have to know which noise has existence has in the digital image. We have presented the solution of all these problems through the review of noise models.

In this paper, the literature survey is based on several types of noise theory. We start noise, different types of noise models. Noise is a random signal (6) Noise is an unwanted signal which is used to destroy the image original quality. Image destroyed by some noise such as Gaussian noise, Salt and Pepper noise, Quantization, Rayleigh noise, Gama noise, Brown noise, Speckle noise, and much fundamental noise. The important sources of noise in the digital images are as follows 1) During the time of image acquisition or transmission 2) acquisition the light level 3) environmental conditions during image acquisition 4) Electronic transmission of image 5) dust particles are present on the scanner screen [7].

II. SEVERAL TYPE OF NOISE MODEL

Noise is an unwanted signal or information which destroys image quality and causes degradation in image quality [8]. During image acquisition or during image transmission a Digital pic is corrupted by noise. There is some common noise in the digital image. It's shown Fig. 1

Fig. 1 Common type of noise

a. Gaussian noise

Gaussian noise is statistical noise which has a probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution [9] [10]. Gaussian noise is also called amplifier noise. The primary source of Gaussian noise is image acquisition e.g Sensor noise introduced by poor illumination or high temperature. This noise is called as the main part of the "real noise" in an image sensor, which is known as a constant noise level in dark areas of the image [11]. To estimate the mean of a stationary Gaussian random variable Gaussian distribution has an important property, one can't do any better than the linear average. This makes Gaussian noise a worst-case scenario for nonlinear image restoration filters, in the sense that the improvement over linear filters is least for Gaussian noise. To improve on linear filtering results, nonlinear filters can exploit only the non-Gaussianity of the signal distribution [12]. The noise is independent of the intensity of the pixel value at each point.

The PDF of a Gaussian random variable is given byF

$$(g) = \sqrt{\frac{1}{\sqrt{2\pi\sigma 2}}} \, {}^{-\frac{(g-\mu)2}{2\sigma 2}}$$

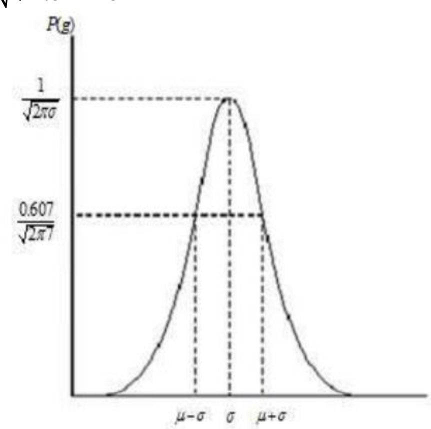

Figure: 2 PDF of Gaussian noise [6]

F (g) = Gaussian distribution noise in image

σ = Standard deviation
μ = mean value

Gaussian noise curve can be looked like in bell-shaped due to this equal randomness the normalized. The PDF of this noise model shows that 70% to 90% noisy pixel values of the degraded image in between μ− σ and μ+ [6]. The image in Fig. 3a shows the original image and Fig. 3b shows the effect of Gaussian noise on the original image

Fig. 3(a)-Original Image
Fig. (3b)-Gaussian Noise

b. Salt and pepper noise (Impulse noise)

Salt-and-pepper noise is a sparsely occurring white and black pixels sometimes seen on images. Median filter or morphological filter methods considered as a common reduction method of this type of noise [13, 14]. Image quality is affected by noise as a result of information loss and unsatisfying visual effects. Salt and pepper noise one of most diminution of the image quality. This is also called impulse noise, random noise, or spike noise.***There are many causes to occurring of salt and pepper such as a defect of the camera sensor, software failure, or hardware failure in the image capturing or transmission***. Duo to these problems, Salt and pepper noise, only a proportion of all the image pixels are corrupted whereas other pixels are non-noisy[15]. The value of salt and pepper may be either minimum (0) or maximum (255). The typical value for pepper noise is close to 0 and salt noise is close to 255.

$$\eta(x,y) = \begin{cases} 0, \, pepper\ noise \\ 255, \, Salt\ noise \end{cases}$$

The PDF of impulse noise is given by

$$P(z) = \begin{cases} p\ a & \text{For z=a} \\ pb & \text{For z=b} \\ 0 & \text{Other} \end{cases}$$

P(z) = Probability density function
If a>b, intensity 'a' will appear as light dot in the image else intensity 'b' appears like a dark dot.

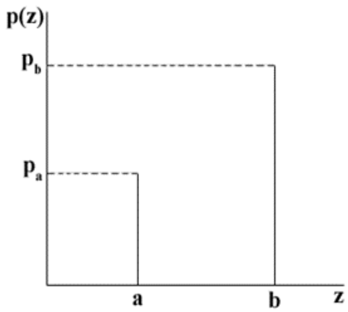

Fig. 4 PDF of Salt and Pepper Noise

Here we will meet two spikes one is for the bright region (where the gray level is less) called 'region a' and another one is the dark region (where the gray level is large) called 'region b', we have clearly seen here the PDF values are minimum and maximum in 'region a' and 'region b', respectively [16]. The image in Fig. 5 illustrates of Salt and pepper noise.

Fig: 5 Salt and pepper noise

c. Quantization noise

Inherent in the amplitude quantization process is called quantization noise. It happens when analog data convert into digital data.

$SNR_{dB}=20\log_{10}(P_{max}-P_{min})/\sigma_n$ [17]

Where *n* Standard deviation of noise, when input is full amplitude sine wave SNR becomes

SNR □□6*n* □□1.76 dB [18]

Where, n is number of bits. It has an approximately uniform distribution.That's why it is referred as uniform noise[9]. Its PDF is shown in Fig. 6.

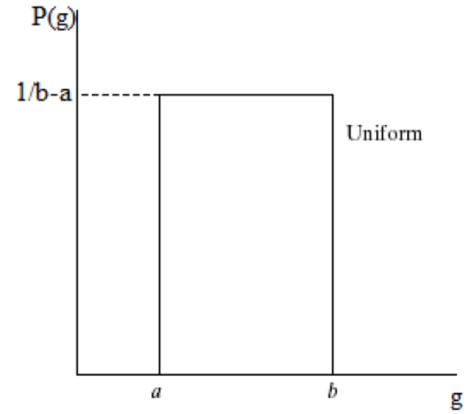

Fig: 6Unifrom noise

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

Their mean $\mu = \frac{a+b}{2}$ and variance $\sigma = \frac{(b-a)2}{12}$ ………………… [19]

d. Gama noise

Gamma noise can be generally seen in the laser-based images and it obeys the Gamma distribution. Its PDF is shown in Fig. 8.

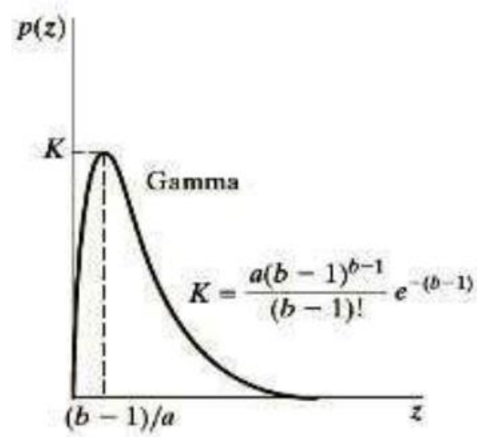

Fig: 7 PDF of Gama Noise

$$P(z) = \begin{cases} \frac{a^b z^{b-1}}{(b-1)!} e^{-az}, \text{ for } z \ge 0 \\ 0, otherwise \end{cases}$$ …………………..(20)

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

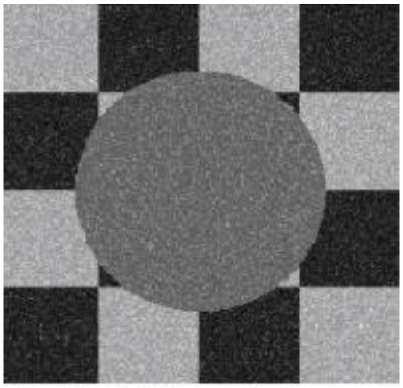

Fig. 8 Gama noise

e. Rayleigh noise

Rayleigh noise presents in radar range images. In Rayleigh noise, the probability density function is given as [21].

$$P(z)=\begin{cases} \frac{2}{b}(g-a)e^{\frac{-(g-a)2}{b}}, & for g \geq a \\ 0, & g < a \end{cases}$$
…………………………….[22]

Where, mean $\mu=a+\sqrt{\frac{\pi b}{4}}$ and variance $\sigma^2=\frac{b(4-\pi)}{4}$. Its PDF is shown in Fig. 9.

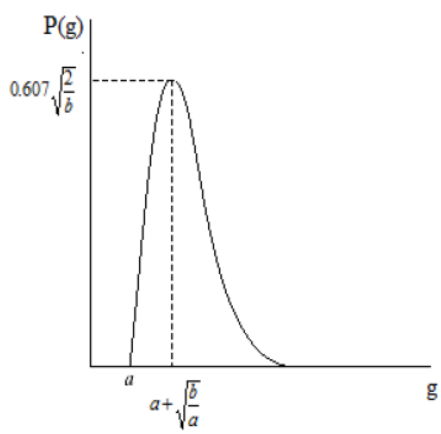

Fig: 9 PDF of Rayleigh noise

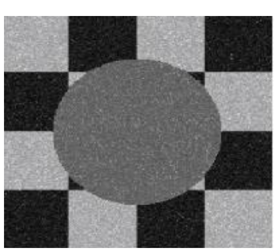

Fig. 10Rayleigh noise

f. Brown Noise(Fractal Noise)

Brown noise is a combination of many colors of noise. Which also includes white noise, pink noise, and blue noise [23]. Brown noise is called Brownian noise because it can change in sound signal from one moment to the next is random. Brown noise which has a lot more energy at lower frequencies than it does at higher frequencies. Brown noise is sometimes referred to as red noise because it's somewhat analogous to red light, which has a low frequency [23]. Statistically fractional Brownian noise is referred to as fractal noise. The fractal noise is caused by natural processes. It is different from the Gaussian process [24-26].

Now a fractional Brownian motion is defined. For each H ∈ (0, 1), a real-valued Gaussian process (BH(t), $t \geq 0$) is defined such that$E[B^H(t)] = 0$ and $E[B^H(t)B^H(s)] = \frac{1}{2}[t^{2H} + s^{2H} - |t - s|^{2H}]$………….. [27]

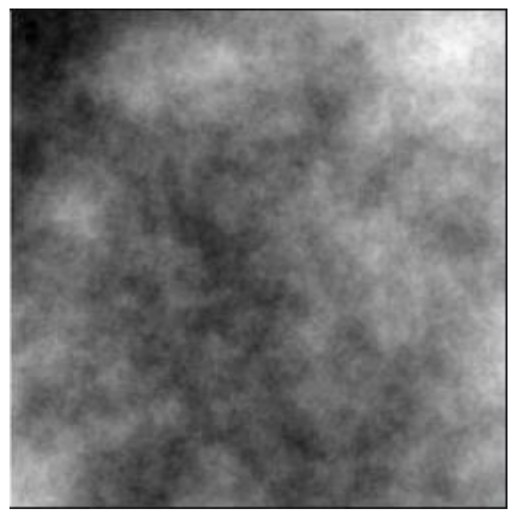

Fig. 11 Brown Noise

g. Speckle noise

Speckle noise is known as multiplicative noise. The interaction between the laser light and the roughness of the PSi surface are causes of speckle-noise [27]. Speckle noise can be modeled as multiplicative noise, with the obtained signal being a product of the original signal and the speckle noise [28]. Now, the multiplicative noise model,

I(i,j)= M(I,j)×N(I,j)

Where (i, j) = a distorted pixel in an image.

M(i, j) = the corresponding noiseless image pixel. According to the multiplicative noise model. [29]

N(i, j)=represents the speckle noise signal.

Speckle noise signalprobability density function follows gamma distribution, which is shown in Fig. 8

f(g)=$\frac{g^{a-a}e^{\frac{-g}{a}}}{a-1!a^{\alpha}}$and Fig. 12 shows the effect of speckle noise.

Fig: 12speckle noise

III. CONCLUSION

Noise can be seen in images during acquisition and transmission. Noise models are a very vital part of image processing. So, without any proper knowledge of noise models, it is very hard to remove the noise from the original image.

In this review paper, we have reviewed the various types of noise in digital image processing. The noise model can be identified which helps for image processing. Using Probability Density Function (PDF) can get mean, median, and gray levels in digital image processing.

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