Noise Models:

The principal source of noise in digital images arises during image acquisition and or transmission. The performance of imaging sensors is affected by a variety of factors, such as environmental conditions during image acquisition and by the quality of the sensing elements themselves. Images are corrupted during transmission principally due to interference in the channels used for transmission. Since main sources of noise presented in digital images are resulted from atmospheric disturbance and image sensor circuitry, following assumptions can be made i.e. the noise model is spatial invariant (independent of spatial location). The noise model is uncorrelated with the object function.

GAUSSIAN NOISE:

These noise models are used frequently in practices because of its tractability in

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

both spatial and frequency domain. The PDF of Gaussian random variable is

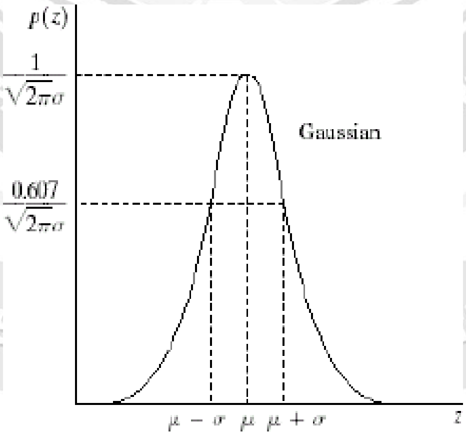


Fig3.2.1: probability density function of guassian noise

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition, 2010.-Page- 315)

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

Source of Gaussian Noise :

The Gaussian noise arises in an image due to factors such as **electronic circuit noise** and **sensor noise** due to poor illumination. The images acquired by image **scanners** exhibit this phenomenon.

RAYLEIGH NOISE:

Unlike Gaussian distribution, the Rayleigh distribution is no symmetric. It is given by the formula.

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

The mean and variance of this density is

$$m = a + \sqrt{\pi b/4}, \sigma^2 = \frac{b(4 - \pi)}{4}$$

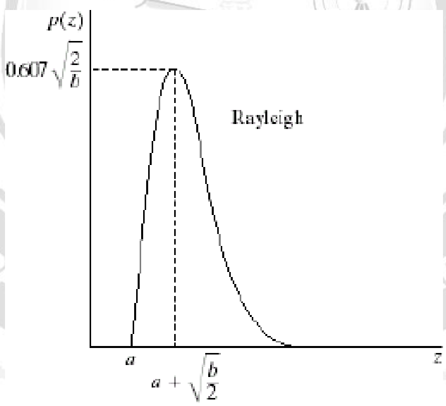


Fig3.2.2: probability density function of Rayleigh noise

Source: Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing

Pearson, Third Edition, 2010.-Page- 315

(iii) GAMMA NOISE:

The PDF of Erlang noise is given by

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

The mean and variance of this density are given by

$$\text{mean} : \mu = \frac{b}{a} \quad \text{variance} : \sigma^2 = \frac{b}{a^2}$$

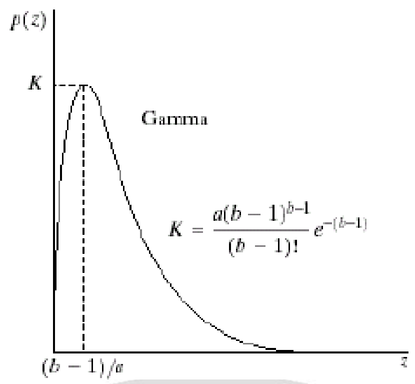


Fig3.2.3: probability density function of Gamma noise

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition, 2010.-Page- 315)

Its shape is similar to Rayleigh disruption. This equation is referred to as gamma density it is correct only when the denominator is the gamma function.

(iv) EXPONENTIALNOISE:

Exponential distribution has an exponential shape.

The PDF of exponential noise is given as

$$p_z(z) = \begin{cases} ae^{-az} & z \geq 0 \\ 0 & z < 0 \end{cases}$$

Where a>0. The mean and variance of this density are given by

$$m = \frac{1}{a}, \quad \sigma^2 = \frac{1}{a^2}$$

Exponential pdf is a special case of Erlang pdf with *b* =1.

Used in laser imaging.

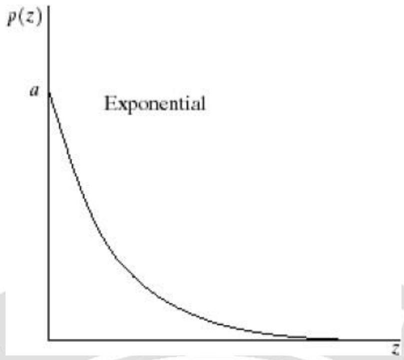
(v) UNIFORM NOISE:

The PDF of uniform noise is given by

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

The mean and variance of this noise is

$$m = \frac{1}{a}, \quad \sigma^2 = \frac{1}{a^2}$$



$$m = \frac{a+b}{2}, \quad \sigma^2 = \frac{(b-a)^2}{12}$$

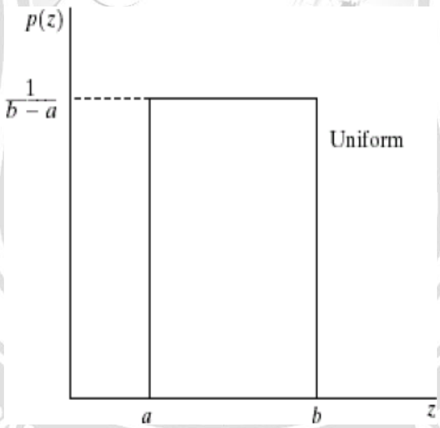


Figure 3.2.4 shows a plot of the Rayleigh density. Note the displacement from the origin and the fact that the basic shape of this density is skewed to the right. The Rayleigh density can be quite useful for approximating skewed histograms.

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition,
2010.-Page- 315)

Impulse (salt-and-pepper) noise (bipolar) is specified as

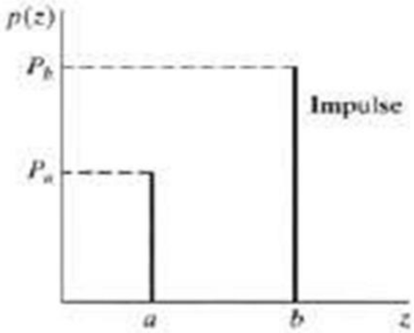


Figure3.2.5(b) shows a plot of the Rayleigh density. Note the displacement from the origin and the fact that the basic shape of this density is skewed to the right. The Rayleigh density can be quite useful for approximating skewed histograms.

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition,2010.- Page-315)

If *b*>*a*, intensity *b* will appear as a light dot on the image and *a* appears as a dark dot If either *Pa* or *Pb* is zero the noise is called *unipolar*. If neither probability is zero, and especially if they are approximately equal, impulse noise value will resemble salt and pepper granules randomly distributed over the image. For this reason, bipolar impulse noise is called salt and pepper noise.

In this case, the noise is signal dependent, and is multiplied to the image.

$$p_z(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases} \qquad b > a$$