Unit-2

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Image degradations -

Image degration means image quality diminished or compromised. This can happen for a number of causes, included noise, blur or compression.

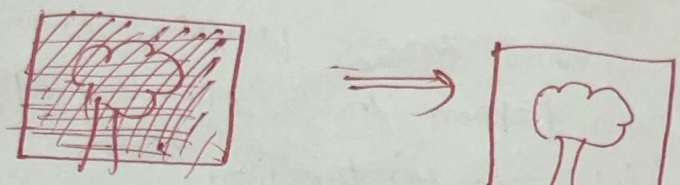
1) **Noise** - Noise can be introduced into image by camera sensor, interference from outside sources, or quantization mistake during image processing.

2) **Compression** - Can also lead to image degradation as it involves reducing the size of image by removing or approximate certain image data. This can result in lossy compression, where some of original data is permanently lost or lossless compression, where the original data can be recovered exactly.

3) **Blur** - Can also cause image degradation as it can make the image appear out of focus or reduce the sharpness of image. Blur can be created by movement of camera or the subject, the use of low quality lens.

Image Restoration

* Image restoration attempts to restore image that have been degraded
  - Identify the degradation process and attempt to reverse it
  - Almost similar to image enhancement, but more objective.



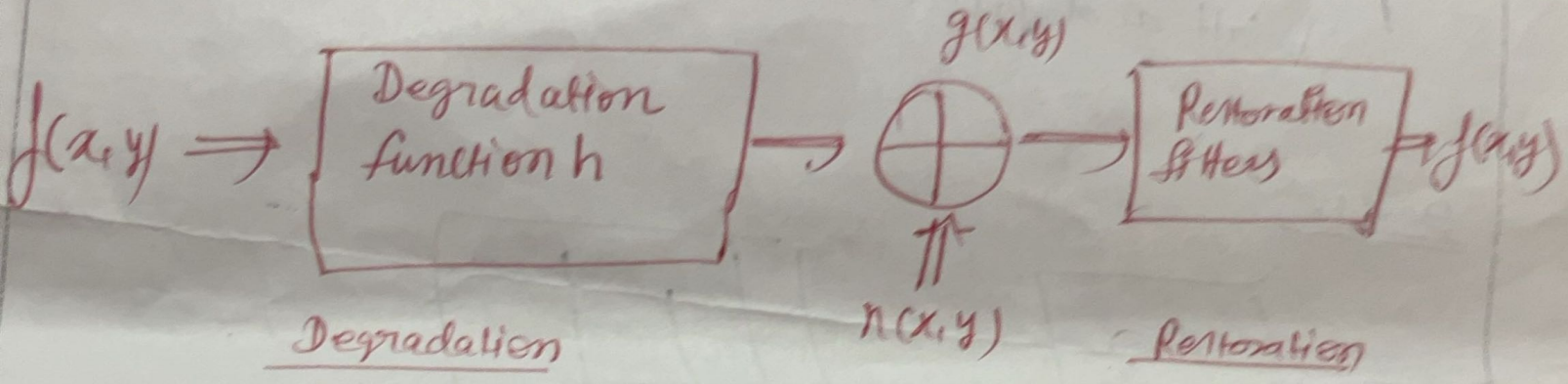
Degraded Image

Restored Image

⇒ Basic difference between Image Enhancement & Image Restoration-

Image Enhancement	Image Restoration
(1) Concerning the extraction of image features	(1) Concerning the restoration of degradation.
(2) Difficult to quality performance	(2) Performance can be quantified.
Subjective - making an image look better.	(3) objective - Recovering the original image.

Image degration model –



objective – to restore a degraded [distorted image to its original content and quality.

⇒ degradation model can be expressed by –

Spatial domain $g(x,y) = h(x,y) * f(x,y) + n(x,y)$

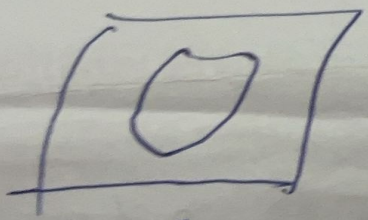
frequency domain : $G(u,v) = H(u,v)\ F(u,v) + n(u,v)$

matrix $= G = Hf + n$

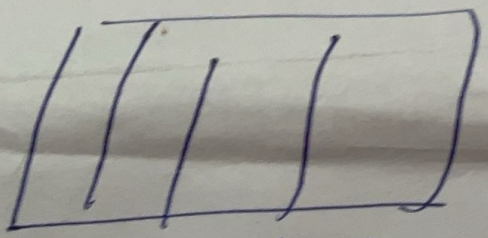
Different model of Noise model $n(x,y)$

- Gaussian
- Rayleigh
- Erlang or Gamma
- Exponential
- uniform
- pulse
- salt and pepper noise

Double

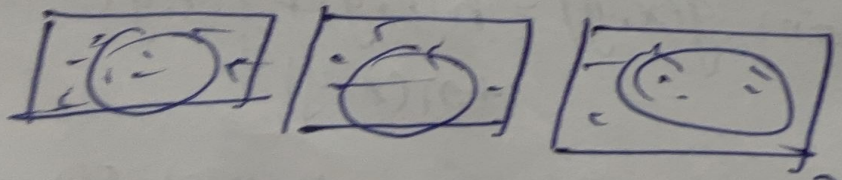


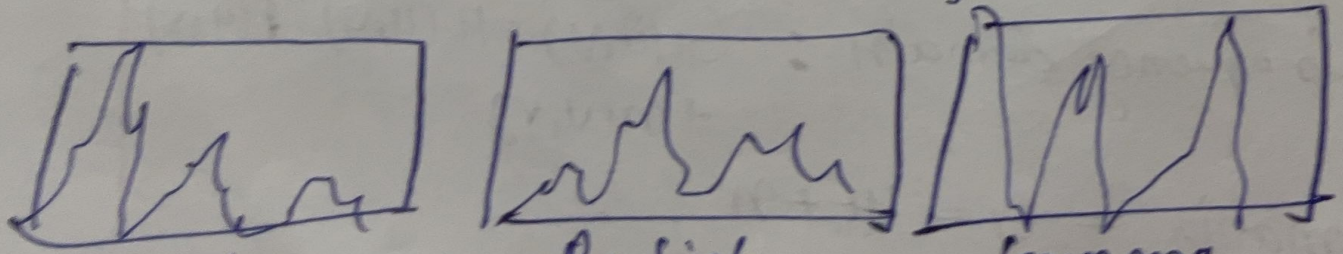
original image



original Image histogram

Noise model effects





Gaussian Rayleigh Gamma

Noise models in digital image processing -

* Noise basically introduced in digital image acquisition and transmission. Images are also corrupted during the transmission process due to non-ideal channel characteristics
* This part includes degradation model. Mathmatically we can write the following:-

$$g(x,y) = h(x,y) * f(x,y) + n(x,y)$$

* * represents convolution in spatial domain

Types of Noise models

→ 1) **Gaussian Noise model** - Basic cause of Gaussian noise is electronic circuit noise and sensor noise due to poor illumination or high temperature

$$f(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(z-m)^2}{2\sigma^2}}$$

z = reference (noise) gray value. m is the mean
σ is standard deviation
σ^2 (Standard deviation) is usually referred to as Variance.

→ 2) Rayleigh Noise Model - Rayleigh noise is usually used in range imaging

$$P(z) = \frac{a^b z^{b-1}}{(b-1)!} e^{-az} \text{ for } z \geq 0 \text{ and } P(z) = 0 \text{ otherwise}$$

$$P(z) = \frac{2}{b}(z-a)\, e^{-\frac{(z-a)^2}{b}} \text{ for } z_1 \text{ and } P(z) = 0 \text{ otherwise}$$

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

$$\sigma^2 = \frac{b(4-\pi)}{4}$$

This noise is 'one-sided' and density function is skewed.

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→ 3) Erlang (Gamma) Noise model — Gamma noise are density finds application in laser imaging.

$$P(z) = \frac{a^b z^{b-1}}{(b-1)!} e^{-az} \text{ for } z \geq 0 \text{ and } P(z) = 0 \text{ otherwise}$$

The mean and variance are given by -

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

The noise is 'one-sided' and density function is skewed.

→ 4) Exponential Noise Model — Exponential noise is also commonly present in cases of laser Imaging.

where $a > 0$

The mean and variance are given by -

$$\mu = 1/a \quad , \quad \sigma^2 = 1/a^2$$

$$P(z) = a e^{-az} \text{ for } z \geq 0 \text{ and } P(z) = 0 \text{ otherwise}$$

This is special case of Erlang (Gamma) noise with $b = 1$.

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→ 5) Uniform Noise – uniform noise is not practically present but is often used in numerical simulations to analyze systems.

where $a > 0$, b is an integer.

The mean and Variance are given by –

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

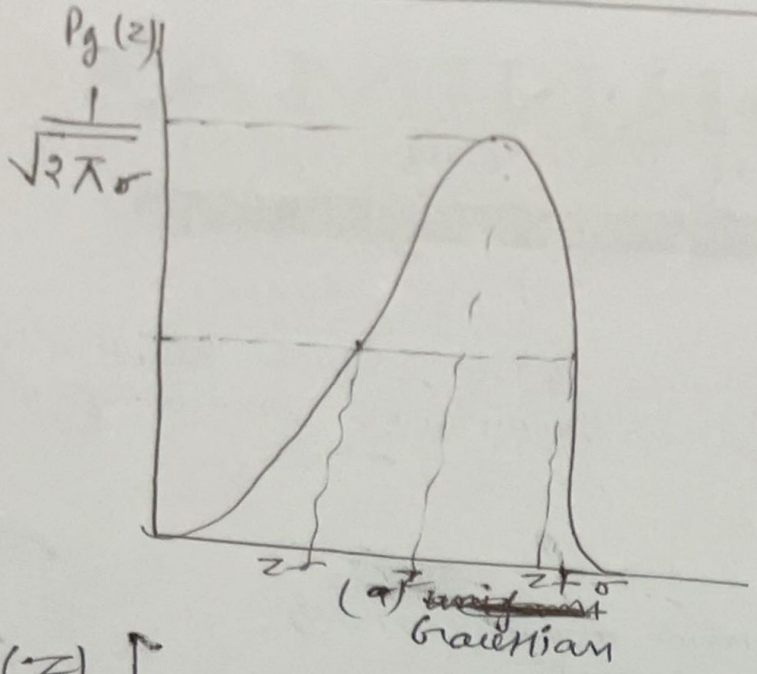
$$P(z) = \frac{1}{b-a} \text{ if } a \le z \le b, \text{ and } P(z) = 0 \text{ otherwise}$$

→ 6) Impulse Noise (Salt and pepper Noise) –

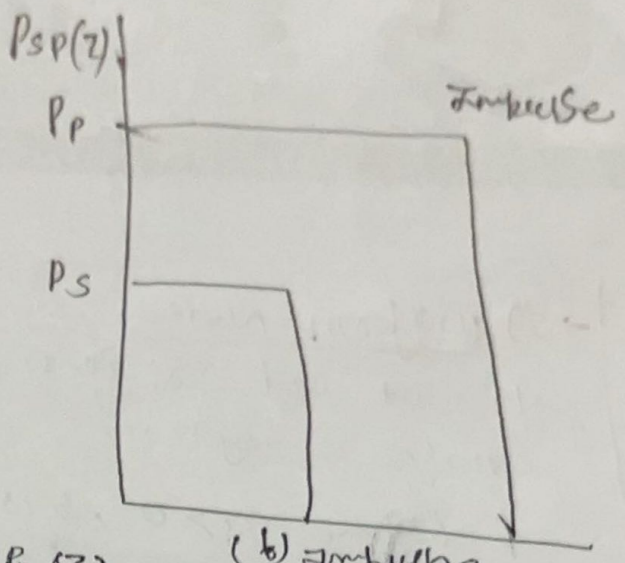
$$P(z) = P_a \text{ for } Z = a, P(z) = P_b \text{ for } Z = b, P(z) = 0 \text{ otherwise}$$

If $b > a$, intensity b will appear as a light dot in image. Conversly, level a will appear like black dot in the image. Presence of white and black granual called salt n pepper noise. Impulse noise such as faulty switching in camera.

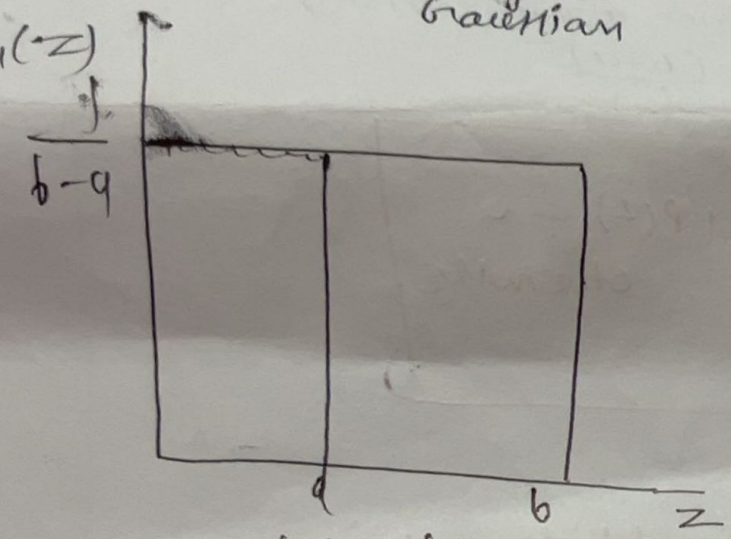
Representation of Different Noise models



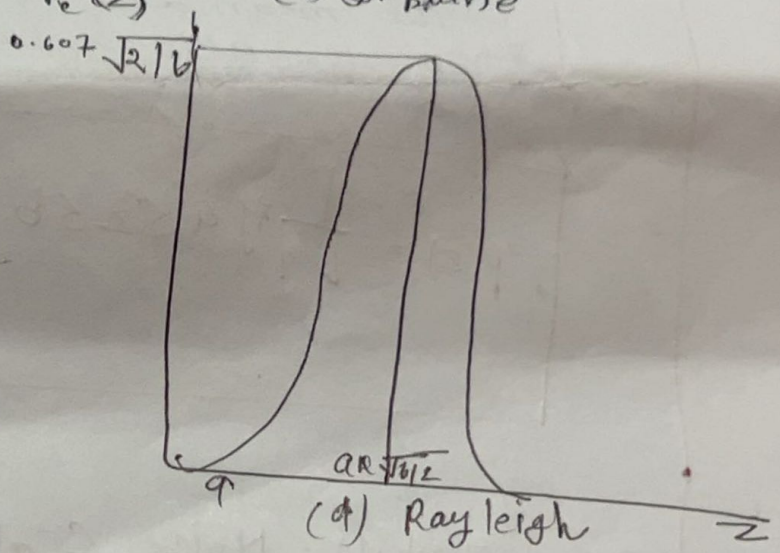
(a) Gaussian



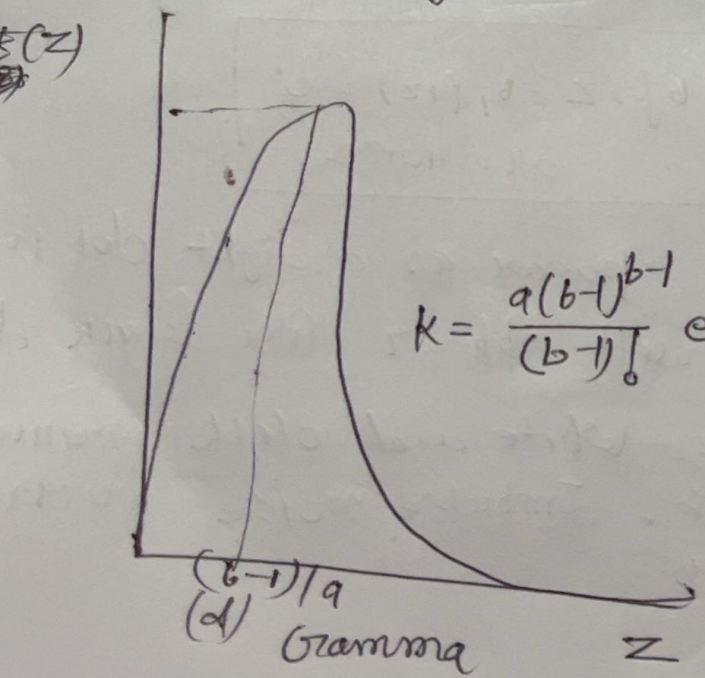
(b) Impulse



(c) uniform

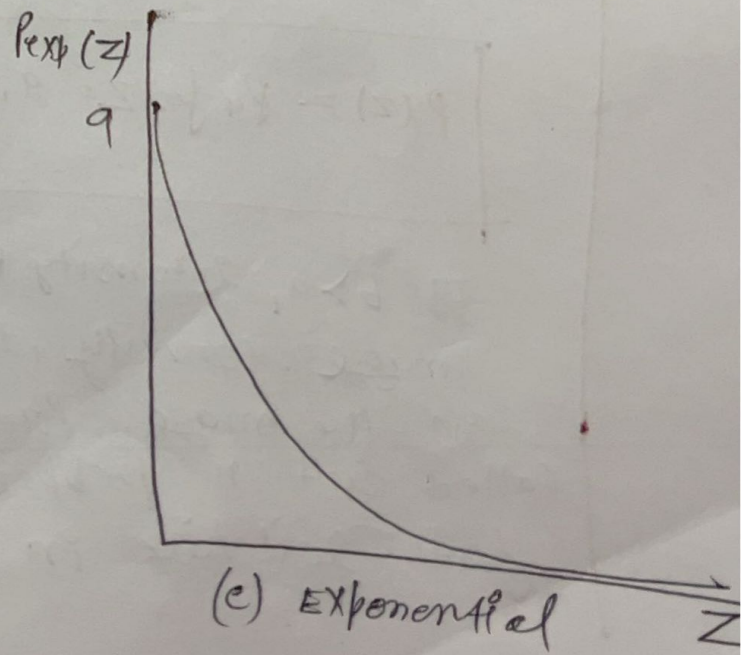


(d) Rayleigh



(d) Gamma

$$K = \frac{a(b-1)^{b-1}}{(b-1)!} e^{-(b-1)}$$



(e) Exponential

Representation of effects of Noise Images & Histograms

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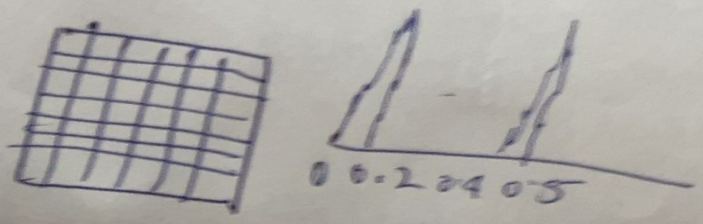
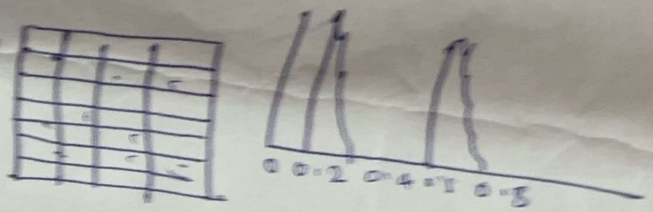
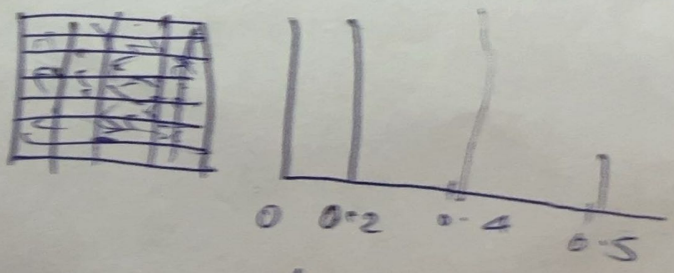
- Gaussian



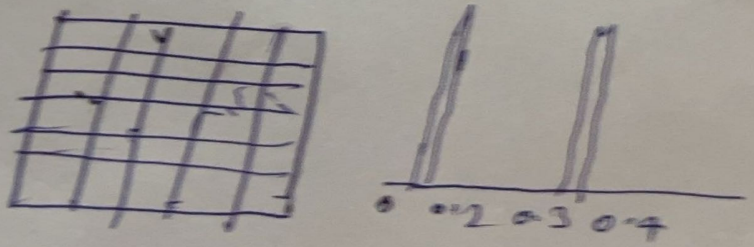
- Exponential



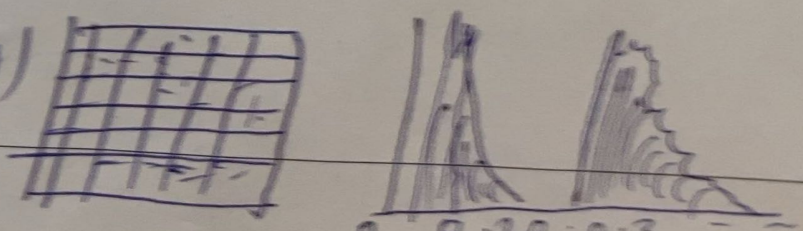
- Impulse (Salt n pepper)



- Raykigh



- Gamma (Erlang)



- uniform