5 Q Describe the Model of image degradation restoration process.

Ans: Model image degradation as an operator that together with an additive noise term. Operates on input image $f(x,y)$ to produce a degraded image $g(x,y)$.

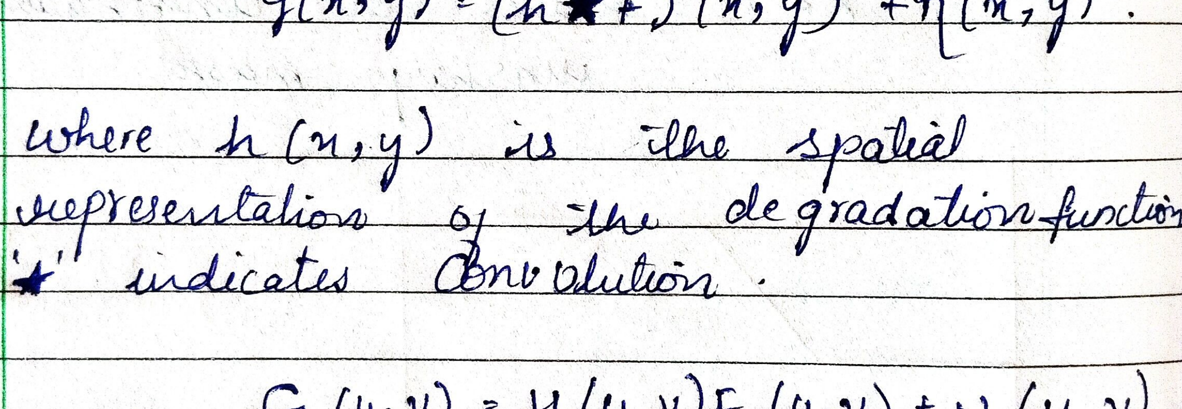
The degraded image is given in the spatial domain by.

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

where $h(x,y)$ is the spatial representation of the degradation function. "$\star$" indicates convolution.

$$G(u,v) = H(u,v)F(u,v) + N(u,v).$$

The capital letters are the Fourier transformations.



69) Define Noise Module and explain different noise probability density functions

Ans: The principal source of noise in digital images arise during image acquisition and /or transmission.

- The performance of imaging sensors is affected by variety of environmental factors during image acquisation. In acquiring images with CCD Camera, light levels & Sensor temperature are major factors effecting the amount of noise in the resulting image.

→ Some important noise probability density functions.

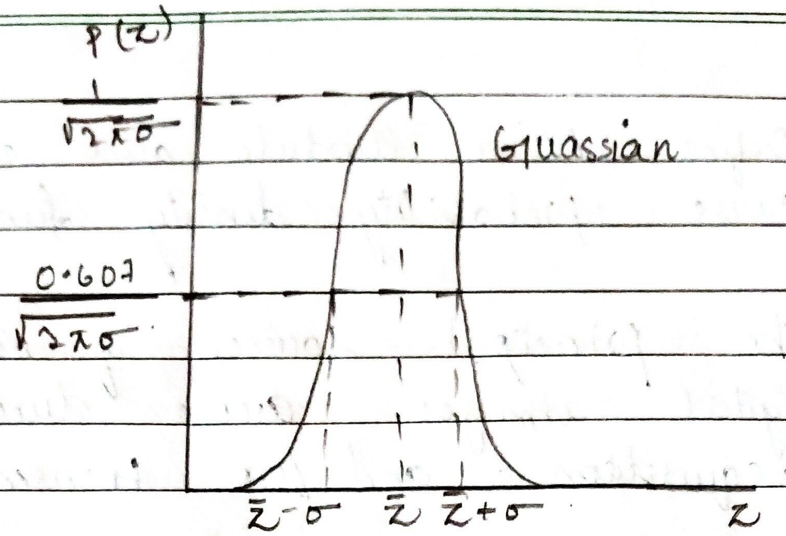
(i) Guassian Noise :-

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

where z represent intensity

$\bar{z}$ is mean (average of z)

σ standard deviation.



(ii) Rayleigh Noise

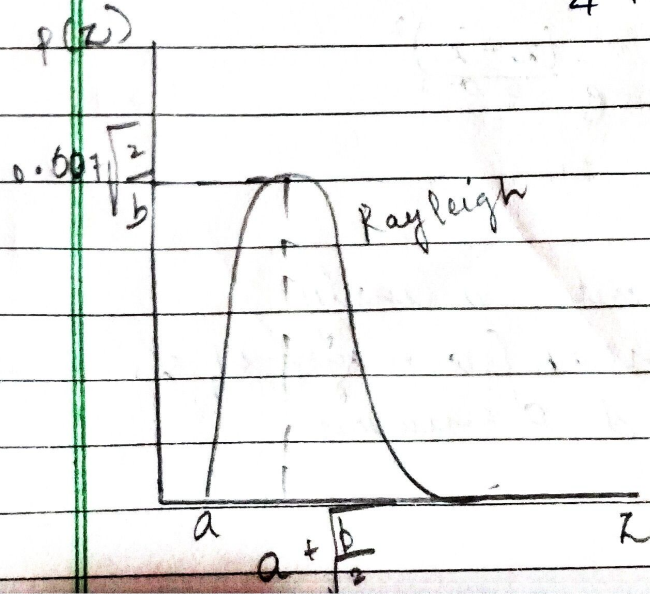
$$p(z) = \begin{cases} \frac{2}{b}(z-a)e^{-(z-a)^2/b} & z \geq a \\ 0 & z < a \end{cases}$$

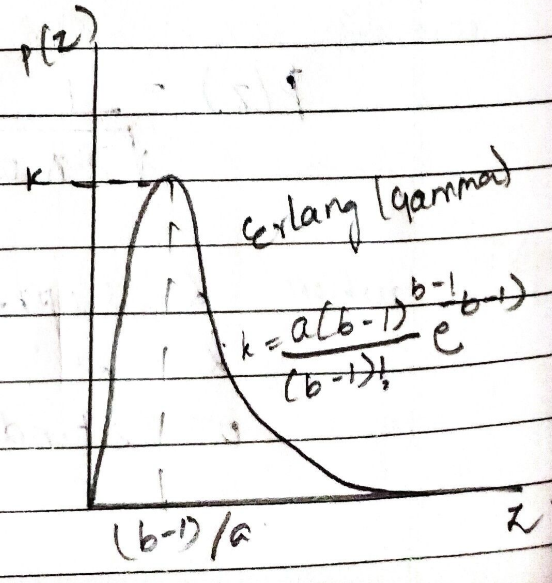
The mean & variance of z when this random variable is characterized by

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

&

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





(iii) Erlang (Gamma) Noise

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

! indicates factorial.

mean & variance are.

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

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

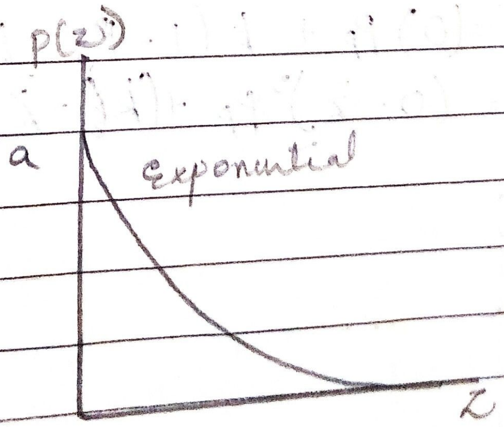
(iv) Exponential Noise :-

$$p(z) = \begin{cases} a e^{-az} & z \geq 0 \\ 0 & z < 0 \end{cases}$$

mean & variance

$$\bar{z} = \frac{1}{a} \text{ \&}$$

$$\sigma^2 = \frac{1}{a^2}.$$



(v) Uniform Noise

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

mean & Variance

$$\bar{z} = \frac{a+b}{2}$$

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

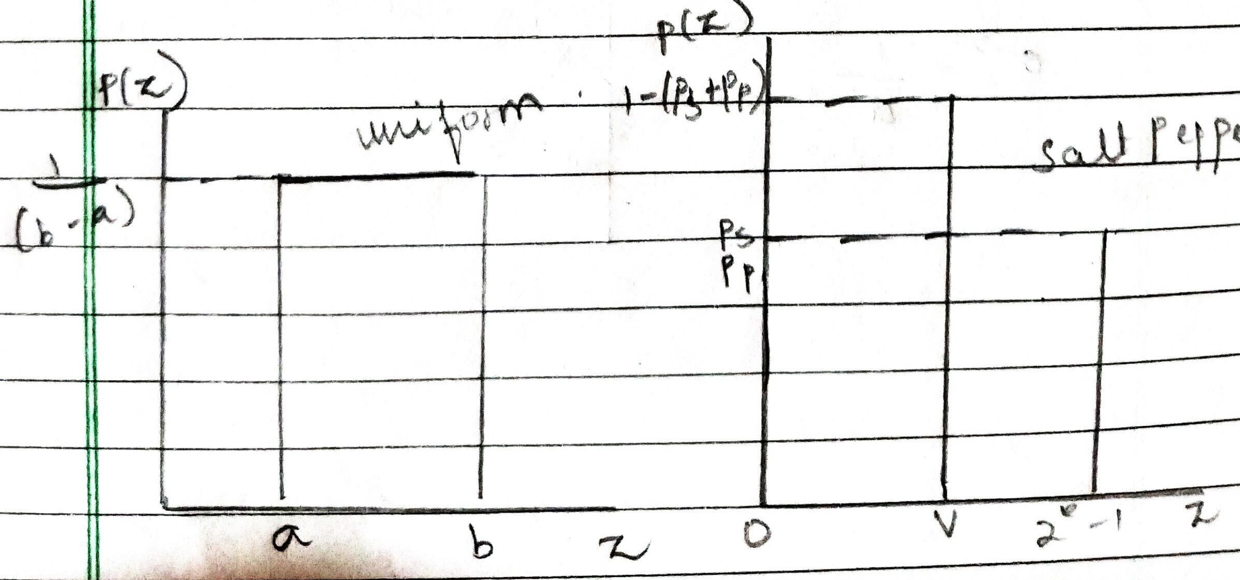
(vi) Salt & pepper Noise

$$p(z) = \begin{cases} P_s & \text{for } z = 2^k - 1 \\ P_P & \text{for } z = 0 \\ 1-(P_s+P_P) & \text{for } z = v \end{cases}$$

mean & Variance =

$\bar{z} = (0) P_P + k(1 - P_s - P_P) + (2^k - 1) P_s$

$\sigma^2 = (0-\bar{z})^2 P_P + (k - \bar{z})^2 (1 - P_s - P_P) + (2^k - 1)^2 P_s$



18. Describe restoration in the presence of noise only.

Ans when an image is degraded only by additive noise it becomes

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

&

$$G(u,v) = F(u,v) + N(u,v)$$

$N(u,v)$ can be substracted from $G(u,v)$ to obtain an estimate of original image

- Spatial filtering is the method of choice for estimating $f(x,y)$ in situation when only additive random noise is present.

19. Describe mean filters:-

(i) → Arithmetic Mean filter:-

It is the simplest of the mean filter. Let S_{xy} represent the set of coordinates in a rectangular subimage window of size $m \times n$. center point (x,y)

$$\hat{f}(x,y) = \frac{1}{mn} \sum_{(r,c) \in S_{xy}} g(r,c)$$

r & c are row and column coordinates of the pixels contained in the neighbourhood S_{xy}

(ii) → Geometric Mean filter :-

$$\hat{f}(x,y) = \left[\prod_{(r,c)\in S_{xy}} g(r,c) \right]^{\frac{1}{mn}}$$

where $\prod$ indicates multiplication.

(iii) → Harmonic Mean filter :-

$$\hat{f}(x,y) = \frac{mn}{\sum_{(r,c)\in S_{xy}} \frac{1}{g(r,c)}}$$

This mean filter works well for salt noise but fails for pepper noise.

(iv) → Contraharmonic Noise Mean Filter :-

$$\hat{f}(x,y) = \frac{\sum_{(r,c)\in S_{xy}} g(r,c)^{Q+1}}{\sum_{(r,c)\in S_{xy}} g(r,c)^{Q}}$$

Q is order of filter.

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Q9 Describe Order Static filters?

Ans (i) Median filter :- It is the best know order static filter in image processing. as the name implies replace the value of pixel by the median of intensity level.

$$\hat{f}(x,y) = \underset{(r,c)\in S_{xy}}{\text{median}} \{g(r,c)\}.$$

S_{xy} = subimage

median filter are quite popular because of types of random noise.

(ii) → Max and Min filters

$$\hat{f}(x,y) = \underset{(r,c)\in S_{xy}}{\max} \{g(r,c)\}$$

This filter is useful for finding the brightest points in an image or for eroding dark regions adjacent to bright areas.

The 0^{th} percentile filter is the min filter

$$\hat{f}(x,y) = \underset{(r,c)\in S_{xy}}{\min} \{g(r,c)\}.$$

It is used to find the darkest point in an image

(iii) → Midpoint filter :-

It Computes the midpoint between the maximum & minimum values in the area Compressed.

$$\hat{f}(x, y) = \frac{1}{2}\left[\max_{(r,c)\in S_{xy}}\{g(r,c)\} + \min_{(r,c)\in S_{xy}}\{g(r,c)\}\right]$$

(iv) → Alpha Trimmed Mean filter

Suppose we delete the $d/2$ lowest & $d/2$ highest intensity values of $g(r,c)$ in neighbourhood S_{xy}. let $g_R(r,c)$ represent the remaining $mn-d$ pixels in S_{xy}.

- A filter formed by averaging these remaing pixels is known as alpha trimmed mean filter

$$\hat{f}(x, y) = \frac{1}{mn-d} \sum_{(r,c)\in S_{xy}} g_R(r,c)$$

Where d ranges from 0 to $mn-1$ if $d = 0$ then Alpha trimmed reduces to arthemetic mean filter $d = mn-1$ then becomes median filter

10Q Discuss adaptive local noise reduction filter and Adaptive median filter?

Ans: The mean gives a measure of average intensity in the region ones the appearance ~~of an image~~ which the mean is computed & variance gives a measure of image contrast in that region.

- Our filter is to operate on a neighbourhood S_{xy}, centered on coordinates (x, y). It contains the following quantities.
- $g(x,y)$, value of the noisy image at (x,y), σ_η^2 the variance of noise, $\bar{z}_{S_{xy}}$ local average intensity of pixel in S_{xy}, $\sigma^2_{S_{xy}}$ local variance of intensities of pixel in S_{xy}.

1. If σ_η^2 is zero the filter should return simply the value of g at (x,y). This is the trivial, zero noise case in which g is equal to f at (x,y).

2. If the local ~~variable~~ variance $\sigma^2_{S_{xy}}$ is high relative to σ_η^2, the filter

to return a value close to $g^{a}(x, y)$. A high local variance typically is associated with edges & these should be preserved.

3. If the two variance are equal we want the filter to return the arthemetic mean value of pixel in S_{xy}. This condition occurs when the local area has the same properties as the overall image, & local noise is to be reduced by averaging.

$$\hat{f}(x, y) = g(x, y) - \frac{\sigma^2_{\eta}}{\sigma^2_{S_{xy}}} \left[g(x, y) - \bar{z}_{S_{xy}} \right]$$

→ Adaptive Mean Filter :-

An additional benefit of the adaptive meadian filtering can handle noise with probabilities larger than these. It seeks to preserve detail while simultaneously smoothing non-impluse noise. It also works on rectangular neighbourhood S_{xy}.

we use following notations :

Z_{min} = minimum intensity value in S_{xy}
Z_{max} = maximum intensity value in S_{xy}
Z_{med} = median of intensity values in S_{xy}
Z_{xy} = intensity at coordinates (x, y).
S_{max} = maximum allowed size of S_{xy}.

The adaptive median filtering uses two levels: denoted by level A & level B.

Level A : if $Z_{min} < Z_{med} < Z_{max}$, go to level B
else, increase size of S_{xy}.
if $S_{xy} \leq S_{max}$, repeat level A
else, output Z_{med}.

Level B : if $Z_{min} < Z_{xy} < Z_{max}$, output Z_{xy}.
else output Z_{med}.

S_{xy} & S_{max} are odd positive integers greater than 1. Another option in the last step of level A is to ~~sp~~ output Z_{xy} instead of Z_{med}. This produce slightly less blurred result but can fail to detect salt noise.

This algorithm has 3 principal objectives.

- To remove salt pepper noise
- To produce smoothing of other noise that may not be impulsive
- To reduce distortion such as excessive thinning or thickness of object boundaries