UNIT-1:- Basics of DIP, Transformation.

UNIT-2:- Image Enhancement.

UNIT-3 :- Image Restoration.

UNIT-4:- Image Segementation.

UNIT-5:- Image compression.

UNIT-1

FUNDAMENTALS OF DIGITAL IMAGE PROCESSING

* Processing of the digital image by using a digital
* computer is called digital image processing.
* Digital image - We require 2 coordinates (2D) $f(x,y)$.
* Digitizing - converting continuous time to digital

>> The process of digital image using a digital computer is known as digital image processing.

>> A digital image is a two dimensional function, $f(x,y)$ where x and y are spacial plane coordinates and amplitude of 'f' at any pair of coordinates x, y is called the intensity or gray level at that point.

**

=> APPLICATIONS OF DIGITAL IMAGE PROCESSING:-

>> Remote sensing via satellite and other space crafts:-

Tracking of Earth Resources, geographical mapping, prediction of agricultural crops, urban growth. Whether forcasting, flood & fire control and Environmental applications

>> space image applications:-

~~Recognis~~
Recognitions and analysis of objects contained in images from Deep space missions.

>> Image transmission & storage applications:
Broadcast TV, Teleconferencing, communication over networks, and military applications CCTV, security monitoring systems

>> Medical applications:-
X-Rays, CT Scan, ultrasonic imaging, patient monitoring & screening for the detection of tumors.

>> RADAR & SONAR applications:-
Detection and Recognition of various types of targets, guidence for air crafts.

>> Robotics:-
Robotic vision for industrial automation, automatic inspection of Robotic parts.

>> Acoustic imaging applications:-
Zeological exploration, ultra sound imaging

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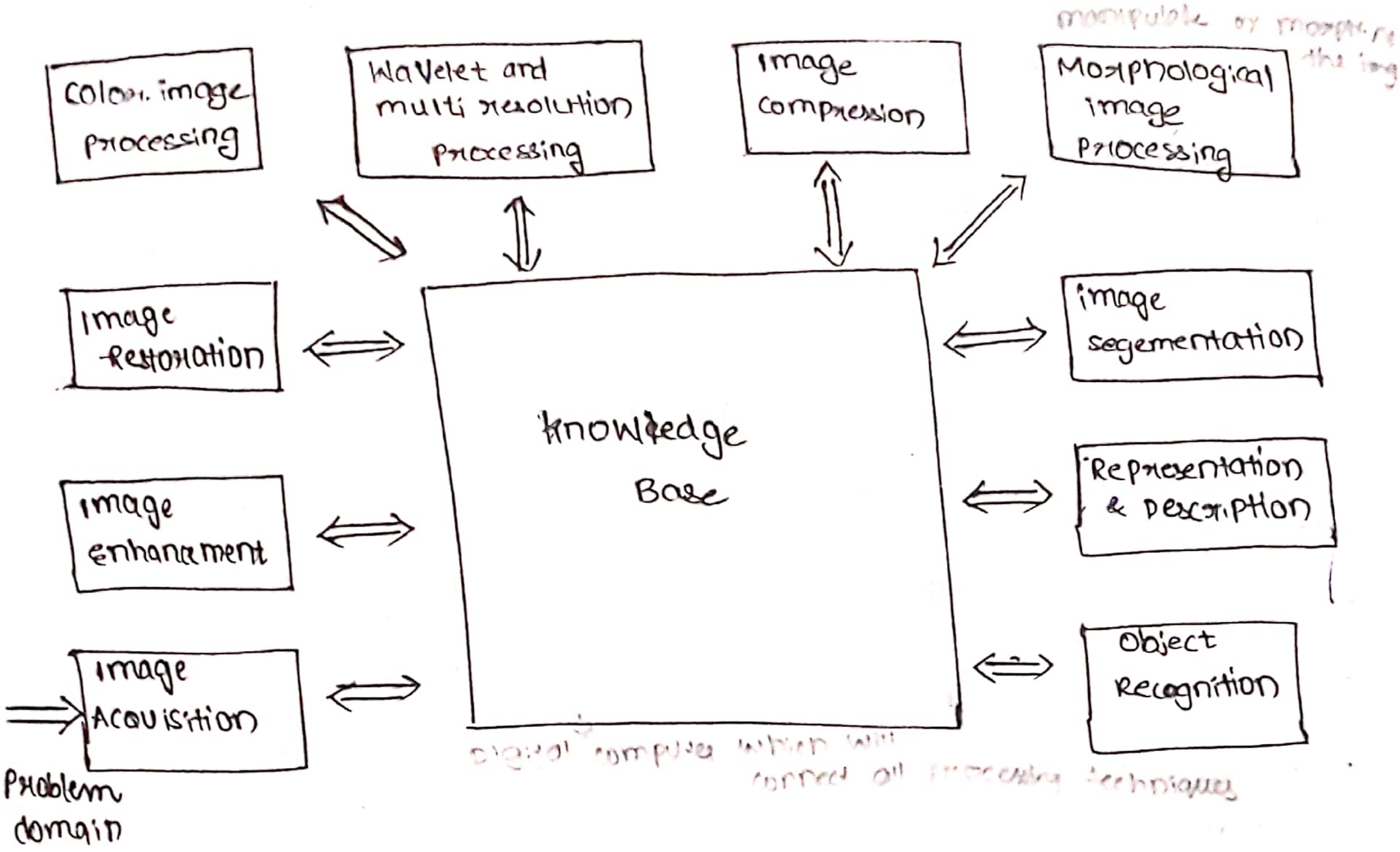
⇒ FUNDAMENTAL STEPS IN DIGITAL IMAGE PROCESSING



In digital image processing the output obtained may be of two types

(i) The outputs are inputs as images

(ii) The outputs are the attributes of the input images.

- IMAGE ACQUISITION:

» The process of aquiring the images is known as image aquisition.

» The sensors used for image aquisition are line sensors, array sensors and single image sensors.

- IMAGE ENHANCEMENT:

» The process in which certain features of interest in an image are being enhanced or improved is known as image enhancement.

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Ex: Increasing the contrast, Magnifying the image, Noise filtering.

The different techniques used for image enhancement are:
—— point process, Mask, Global

(i) spatial domain techniques
(ii) Frequency domain techniques.

- IMAGE RESTORATION:

>> The process of Reconstructing the image by known degradation phenomenon is known as image Restoration.

>> It is based on mathematical models of image degradation.

>> The filtering techniques used in image Restoration are:

(i) inverse filtering
(ii) Wiener filter
(iii) constrained Wiener filter
(iv) Iterative Restoration

- COLOR IMAGE PROCESSING:

>> By using this, human identify thousands of color shades and intensities when compared to gray level images.

>> It is a powerful descriptor that simplifies the object identification from a image.

- WAVELET & MULTI RESOLUTION PROCESSING:

>> These are used for Representing images in various degree of Resolution.
↳ quality of pixels.

- IMAGE COMPRESSION:

>> The process of Reducing the number of ~~to~~ bits for the Representation of image is known as image compression.

» compression techniques are:

lossless compression technique

lossy " "

- MORPHOLOGICAL IMAGE PROCESSING: (by moving structuring element by each & every pixel in an image)

» The process of manipulating or changing the image is known as morphological image processing.

» The methods used are (i) dialation (enlarging the image)
(ii) Erosion (shrinking the image).

- IMAGE SEGEMENTATION:

» The process of subdividing the image into constituent Regions is known as image segementation.

» Methods used for image segementation are:

(i) Threshotding

(ii) clustering.

- IMAGE REPRESENTATION & DESCRIPTION:

» image Representation will measure the quality of an image and Represent in the form of pixels.

» Description is also known as features slection which describes the attributes that results in some quantitative interest.

- OBJECT RECOGNITION:

» It is a process of assigning label or a token to an image based on its descriptors.

- KNOWLEDGE BASE:-

>> It is Digital Processor which connects all the steps in DIP.

⇒ SIMPLE IMAGE MODEL:

>> Image refers to a two dimensional light intensity function denoted by $f(x,y)$, Amplitude of 'f' at spacial coordinates x,y. is a positive scalar quantity given as the intensity of the image at that point.

>> As light is a form of energy $f(x,y)$ must be non-zero and finite.

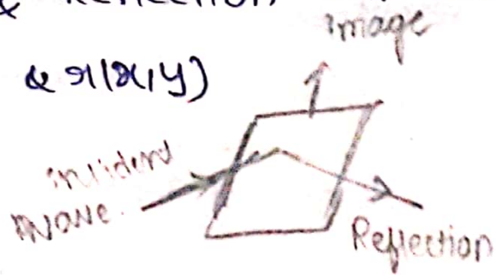
$$\boxed{0 < f(x,y) < \infty}$$

>> The function $f(x,y)$ may be characterized by two components :

(i) The amount of illumination incident on the image.

(ii) Amount of illumination reflected by the image.

>> These are known as illumination & ~~Reflection~~ Reflectance components denoted by, $i(x,y)$ & $r(x,y)$



$$\boxed{f(x,y) = i(x,y) \cdot r(x,y)}$$

>> The intensity of an image at any coordinates x_0, y_0, the gray level at that point is given by,

$$\boxed{L = f(x_0, y_0)}$$

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$\boxed{L_{min} < L < L_{max}}$

>> The interval L_{min}, L_{max} is called the gray level of an image.

$[L_{min}, L_{max}]$

>> In practice we use $[0, L]$ where $K \neq K$ $L = 0$ is considered as 'black'

$L = 1$ is considered as 'white' (monochrome img).

>> The intermediate values are the shades of gray levels.

⇒ <u>SAMPLING AND QUANTIZATION</u>:-

>> Formation of digital image from a continuous image involves two steps :

(i) sampling.

(ii) Quantization.

>> An image is continuous with respect to x and y coordinates and also in amplitude.

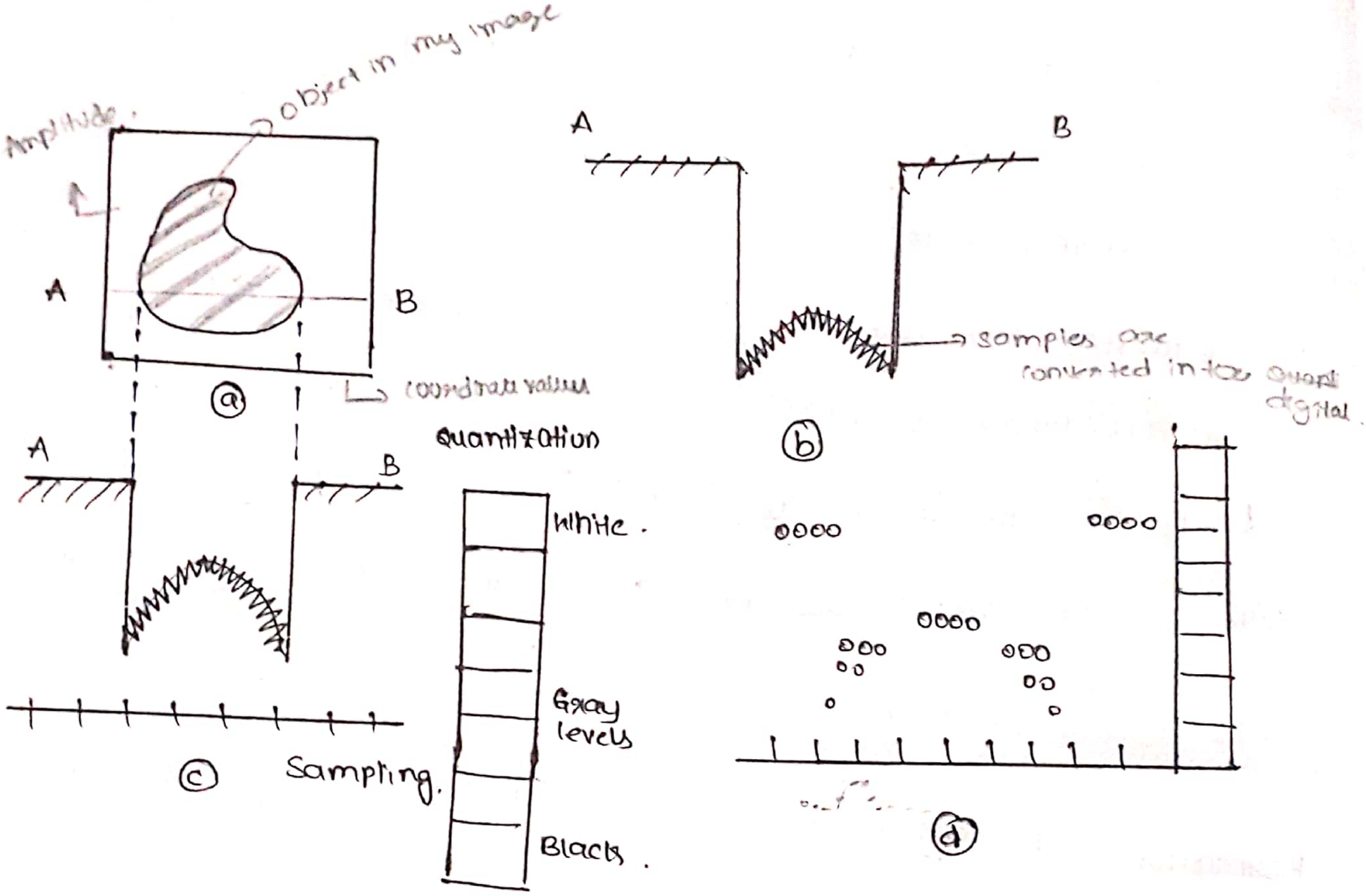
$f(x,y)$

>> Digitizing the coordinate values is called sampling.

(f)

where as digitizing the amplitude values is called quantization.

→ divided entire img to equally



>> consider an image as shown in fig @ along the line Segement AB.

>> Divide the image into equally spaced intervals and convert the samples into discrete.

>> Digitizing the amplitudes will give the quantization levels where 0 is Represented as BLACK color, '1' is Represented as white & the other values are the intermediate values of grey levels.

⇒ DIGITAL IMAGE REPRESENTATION:

» The continuous 2-D image f(x,y) is divided into 'N' ROWS and 'M' columns.

» The intersection of a Row and a column is known as a pixel.

» In matrix Representation f(x,y) is represented as

$$F(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1) \end{bmatrix}$$

» Number of gray levels $\boxed{L = 2^k}$ where, k is the Number of bits to represent a gray level

» The number of bits, 'b' required to store a digital image is given by,

$$\boxed{b = M \times N \times k}$$

» If M = N then 'b' becomes,

$$\boxed{b = N^2 k}$$

» When an image has 2^k gray levels, it is reffered to as 'k' bit image.

Example: An image with 256 gray levels is referred as 8-bit image (i.e $2^8 = 256$).

SPATIAL AND GRAY LEVEL RESOLUTION:-

>> It is the smallest change in the details of an image, it is termed as spatial Resolution

>> The smallest change in the gray levels of an image, it is termed as gray level resolution.

>> The effect caused by an insufficient number of gray levels in an digital image is known as false "contouring".

⇒ RELATIONSHIP WITH PIXELS:-

① Neighbouring
② Connectivity
③ Adjonay
④ Distance measures

(1) NEIGHBOURS OF A PIXEL:-

>> A pixel(P) at coordinates x,y has four horizontal and vertical Neighbours whose coordinates are given by,
$(x,y+1)$, $(x+1,y)$, $(x-1,y)$, $(x,y-1)$

	$(x,y+1)$	
$(x-1,y)$	(x,y)	$(x+1,y)$
	$(x,y-1)$	

>> This set of pixels is called four neighbours of 'p' denoted by $\boxed{N_4(P)}$

>> The four diagonal neighbours of p have the coordinates $(x-1, y+1)$; $(x+1, y+1)$; $(x+1, y+1)$; $(x-1, y-1)$.

$(x-1, y+1)$		$(x+1, y+1)$
	(x, y)	
$(x-1, y-1)$		$(x+1, y-1)$

>> This set of pixels are known as diagonal neighbours of p, denoted by $\boxed{N_D(P)}$

>> ~~MAP~~ $N_4(P)$ and $N_D(P)$ are combinely known eight Neighbours of p denoted by $N_8(P)$

$(x-1, y+1)$	$(x, y+1)$	$(x+1, y+1)$
$(x-1, y)$	(x, y)	$(x+1, y)$
$(x-1, y-1)$	$(x, y-1)$	$(x+1, y-1)$

(8) CONNECTIVITY OF PIXELS:-

>> Consider 'V' as set of intensity values of an image.

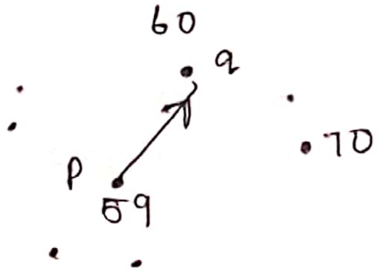
>> consider 'f(p)' pixel is having any intensity value of V then it is said to be 'p' connected to its neighbouring pixel (q)

4-connectivity:-

>> If 'q' belongs to $N_4(P)$ [$q \in N_4(P)$], $f(p) \in V$ then p and q are said to be 4-connectivity.

Example:- consider V = {59, 60, 61}

Let us suppose the center pixel 'P' is 59, q is having the intensity 60 then p and q are said to be 4-connectivity.



8-connectivity:-

If 'q' belongs to $N_8(P)$ [$q \in N_8(P)$], $f(P) \in V$ then p and q are said to be 8-connectivity.

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(3) MIXED CONNECTIVITY:-

» p and q are M-connected, if

(i) $q \in N_4(P)$

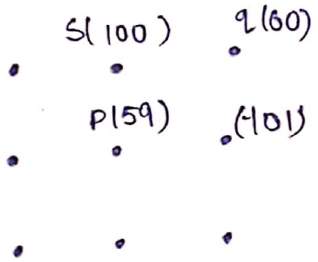
(ii) $q \in N_D(P)$, $f(P)$ & $f(q) \in V$

↑ intersection.

(iii) $N_4(P) \cap N_4(q)$ is empty. (common pixel must be there)

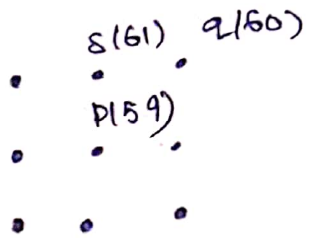
Problem

① consider $V = 59, 60, 61$



$N_4(P) \cap N_4(q)$ is empty (neighbouring pixel intensity values are not within the set)

Thus p and q are M connected.



$N_4(P) \cap N_4(q)$ is not empty Thus p and q are not M connected.

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(3) ADJECENT 'c' OF A PIXEL:-

There are three types of adjecency.

(i) 4 adjecency 'c'

(ii) 8 adjecency 'c'

(iii) M-adjecency 'c'

Let 'v' be the set of gray levels used to defined adjecency.

A pixel 'p' is ~~adj~~ adjecent to pixel 'q' if they are connected.

(i) 4 adjecency 'c'

Two pixels p and q with values from 'v'. Are 4 adjacent if ~~q~~ Q is in the set of N4(P).

i.e $f(p) \in V$, $q \in N_4(P)$

(ii) 8 adjacent c:-

Two pixels p and q with values from 'v'. Are 8 adjacent if q is in the set of N8(P).

i.e, $f(P) \in V$, $q \in N_8(P)$

(iii) M adjacent 'c':-

Two pixels p and q are said to be M adjacent if

(i) q is in $N_4(P)$

(ii) q is in $N_8(P)$ and'

(iii) $N_4(P) \cap N_4(q)$ has no pixels from 'v'

(4)
⇒ DISTANCE MEASURES:-

There are three different types to obtain the distance between the pixels.

consider $p(x,y)$, $q(s,t)$ and $z(u,v)$, we call 'D' to be a distance metric if it follows /full fills the following conditions:

(1) $D(p,q) \geq 0$ $[D(p,q)=0$ if $p=q]$

(2) $D(p,q) = D(q,p)$

(3) $D(p,z) \leq D(p,q) + D(q,z)$

(1) EUCLUIDEAN DISTANCE:-

The distance b/w the pixels p and q is obtained

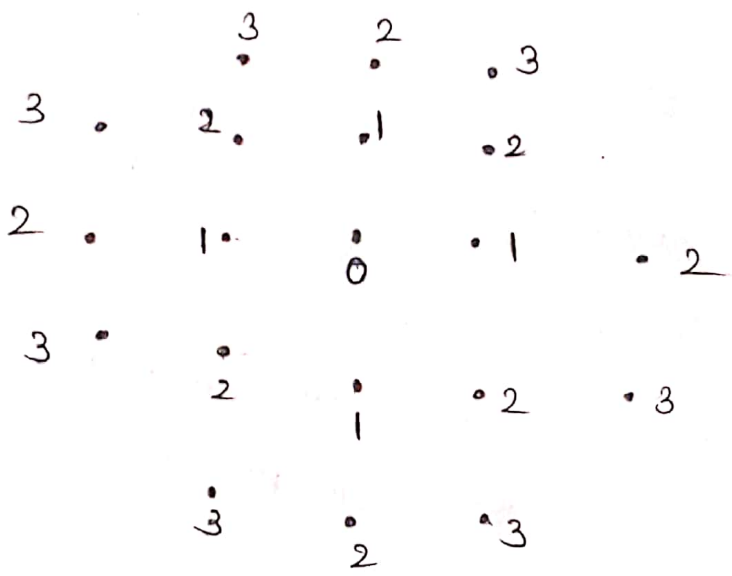
$$\boxed{D_e(p,q) = \sqrt{(x-s)^2 + (y-t)^2}}$$

(2) CITY BLOCK DISTANCE:-

The distance between p and q is obtained

$$\cancel{D_4(P,q) = |(x-s) + (y-t)|}$$

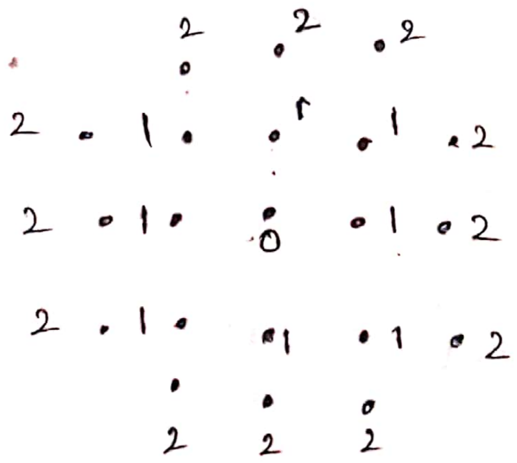
$$\boxed{D_4(P,q) = |x-s| + |y-t|}$$



(3) CHESS BOARD DISTANCE:-

The distance between p and q is obtained

$$\boxed{D_8(P,q) = \max |(x-s), |y-t)|}$$



⇒ TRANSFORMATIONS

⇒ 2-D DFT AND ITS PROPERTIES :-

2 dimensional DFT is given by

$$\boxed{F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi u \frac{x}{M}}}$$

Inverse DFT,

$$\boxed{f(x,y) = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u,v)\, e^{j2\pi u \frac{x}{M}}\, e^{j2\pi v y/N}}$$

⇒ PROPERTIES :-

(1.) Separability :-

It allows 2-D transform to be computed in 2 steps by successive 1-D operations on rows and columns of an image

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi u \frac{x}{M}}$$

Proof:-

$$F(u,v) = \sum_{x=0}^{M-1} \left[\sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi v y/n} \right] e^{-j2\pi u \frac{x}{M}}$$

$$= \sum_{x=0}^{M-1} f(x,v)\, e^{-j2\pi u \frac{x}{M}}$$

$$= F(u,v)$$

(2) Spatial shift property:-

2D DFT of a shifted version of the image $f(x,y)$ i.e $f(x-x_0,y)$ is given by

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi u\frac{x}{M}}$$

$$f(x-x_0,y) \longleftrightarrow e^{+j2\pi x_0\frac{u}{M}} F(u,v).$$

$$DFT\left[f(x-x_0,y)\right] = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x-x_0,y)\cdot e^{-j2\pi u\frac{(x-x_0)}{M}}\, e^{-j2\pi \frac{vy}{N}}.$$

$$DFT\left[f(x-x_0,y)\right] = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x-x_0,y)\, e^{-j2\pi \frac{ux}{M}}\cdot e^{\frac{j2\pi u x_0}{M}}\, e^{-j2\pi\frac{vy}{N}}.$$

$$DFT\left[f(x-x_0,y)\right] = F(u,y)\, e^{-j2\pi x_0 \frac{u}{M}}.$$

(3) PERIODIC PROPERTY:-

$f(x,y)$ is said to be Periodic with period 'M'. if

$(\hat{F}(u,v) = f(P+Pn),) x$

$$F(u,v) = F(u+pN, v+qN)$$

Proof:-

$$\cancel{F(u,v)} \; F(u+pN, v+qN) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) e^{-j2\pi ux/M} \; e^{-j2\pi vy/N}.$$

$$\cancel{F(u,v)} \; F(u+pN, v+qN) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) e^{-j2\pi (u+pN) \frac{x}{M}} . e^{-j2\pi (v+qN) \frac{y}{N}}.$$

$$= \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) e^{-j2\pi \frac{ux}{M}} e^{-j2\pi \frac{vy}{N}}. \; e^{-j2\pi \frac{pNx}{M}} . e^{-j2\pi \frac{pyN}{MN}}$$

$$\therefore F(u+pN, v+qN) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) e^{-j2\pi \frac{ux}{M}} e^{-j2\pi \frac{Nxp}{M}} e^{-j2\pi \frac{vy}{N}} e^{-j2\pi \frac{pyN}{N}}.$$

For any integer values the product of exponential terms is '1'. This proofs that $\boxed{F(u+pN), (v+qN) = F(u,v)}$.

⇒ CONVOLUTION PROPERTY:-

Applying convolution in time domain is multiplication in frequency domain.

$$\boxed{f(x,y) * g(x,y) \longleftrightarrow F(u,v)\ G(u,v)}$$

PROOF:- cosider, applying DFT

$$f(x,y) * g(x,y) = \sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, g(x-\alpha, y-\beta)$$

$$DFT\left[f(x,y) * g(x,y)\right] = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\left[\sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, g(x-\alpha,y-\beta)\right] e^{-j2\pi u\frac{x}{N}}\ e^{-j2\pi vy/N}.$$

inorder to obtain the equations in terms of $x-\alpha', \alpha, y-\beta$, β add and subtract α and β values.

$$DFT[f(x,y) * g(x,y)] = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\left[\sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, g(x-\alpha,y-\beta)\right] e^{-j2\pi u\frac{(x-\alpha+\alpha)}{N}}.\ e^{-j2\pi v\frac{(y-\beta+\beta)}{N}}.$$

$$= \sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\left[\sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, e^{-j2\pi u\frac{\alpha}{N}}.\ e^{-j2\pi v.\frac{\beta}{N}}.\ g(x-\alpha', y-\beta).\ e^{-j2\pi u\frac{x-\alpha}{N}}.\ e^{-j2\pi v\frac{y-\beta}{N}}\right]$$

$$DFT[f(x,y) * g(x,y)] = \left[\sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, e^{-j2\pi u\frac{\alpha}{N}} \cdot e^{-j2\pi v\frac{\beta}{N}}\right]$$

$$\left[\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} g(x-\alpha, y-\beta)\, e^{-j2\pi u\frac{(x-\alpha)}{N}} \cdot e^{-j2\pi v\frac{(y-\beta)}{N}}\right]$$

$$= F(u,v) \cdot G(u,v).$$

⇒ CORRELATION:-

consider $f(x,y)$ and $g(x,y)$ then correlation is being given by

$$\Gamma_{fg} = \sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, g(x+\alpha, y+\beta)$$

gamma

Apply DFT

$$\Gamma_{fg} = \sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\,\alpha$$

$$\Gamma_{fg} = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\left[\sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, g(x+\alpha, y+\beta)\right] e^{-j2\pi u\frac{x}{N}} \cdot e^{-j2\pi v\frac{y}{N}}$$

$$= \sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\left[\sum_{\alpha=0}^{N-1}\sum_{\beta=0}^{N-1} f(\alpha,\beta)\, g(x+\alpha, y+\beta)\right] e^{-j2\pi u\frac{(x+\alpha-\alpha)}{N}}, \; e^{-j2\pi v\frac{(y+\beta-\beta)}{N}}$$

$$= \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} \left[\sum_{\alpha=0}^{N-1} \sum_{\beta=0}^{N-1} f(\alpha,\beta)\, \cancel{g(x+\alpha, y+\beta)}\, e^{-j2\pi \frac{u\alpha}{N}} \cdot e^{j2\pi \frac{u\beta}{N}} \cdot g(x+\alpha, y+\beta) \cdot e^{-j2\pi u \frac{x+\alpha}{N}} \cdot e^{-j2\pi u \frac{y+\beta}{N}} \right]$$

$$= \left[\sum_{\alpha=0}^{N-1} \sum_{\beta=0}^{N-1} f(\alpha,\beta)\, e^{j2\pi u \frac{\alpha}{N}} \cdot e^{j2\pi u \frac{\beta}{N}} \right] \left[\sum_{x=0}^{N-1} \sum_{y=0}^{N-1} g(x+\alpha, y+\beta) \cdot e^{-j2\pi u \frac{(x-\alpha)}{N}} \cdot e^{-j2\pi v \frac{(y-\beta)}{N}} \right]$$

$$= F(-u,-v) \cdot G(u,v)$$

SCALING PROPERTY:-

scaling property is used in order to increase or decrease the size of the image this property is being stated as

$$f(ax, by) \longleftrightarrow \frac{1}{|ab|} F\left(\frac{u}{a}, \frac{v}{b}\right)$$

CONJUGATE SYMMETRY PROPERTY:-

DFT of $F(x,y)$ is $F(u,v)$ then if congugate is applied

$$DFT[f^*(x,y)] \longleftrightarrow F^*(-u,-v)$$

ORTHOGONALITY PROPERTY:-

Orthogonality property of 2D DFT is given by $\frac{1}{N^2}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} a_{u,v}[x,y] \cdot a^{*}_{u',v'}[x,y] = \delta(u-u', v-v')$

where $\delta(u-u', v-v')$ is known as Kronecker delta function.

MULTIPLICATION BY EXPONENTIAL:-

If $DFT[f(x,y)] \longleftrightarrow F(u,v)$ then $DFT\left[e^{\frac{j2\pi x u_0}{N}} \cdot e^{\frac{j2\pi y v_0}{N}} f(x,y)\right] \longleftrightarrow F(u-u_0, v-v_0)$

Proof:-

$$F(u,v) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi \frac{xu}{N}} e^{-j2\pi y \frac{v}{N}} \cdot e^{j2\pi u_0 \frac{x}{N}}\, e^{j2\pi v_0 \frac{y}{N}}.$$

$$F(u,v) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi x \frac{(u-u_0)}{N}} \cdot e^{-j2\pi y \frac{(v-v_0)y}{N}}.$$

$$\boxed{F(u,v) = F(u-u_0, v-v_0)}$$

ROTATIONAL PROPERTY

This property states that if a function is rotated by angle then its fourier transform is also rotated in equal amount.

consider

$$f(x,y) = f(r\cos\theta, r\sin\theta)$$

~~DFT(f(x,y)) =~~

$$DFT[f(r\cos\theta, r\sin\theta)] = F[r\cos\theta, r\sin\theta]$$

$$DFT[f(r\cos(\theta+\theta_0), r\sin(\theta+\theta_0))] = F[r\cos(\theta+\theta_0), r\sin(\theta+\theta_0)]$$

⇒ WALSH TRANSFORM

It is similar to Hadamad. used for image compression. Walsh transform is a real symmetric matrix which is used in digital image processing.

1-D Walsh transform is given by.

$$W(u) = \frac{1}{N}\sum_{x=0}^{N-1} f(x) \prod_{i=0}^{N-1} (-1)^{b_i(x)\, b_{n-1-i}(u)}$$

$$W(u) = \frac{1}{N}\sum_{x=0}^{N-1} f(x)(-1)^{\sum_{i=1}^{N-1} b_i(x)\, b_{n-1-i}(u)}$$

Walsh transform kernel values can be obtained from

$$T(u,x) = T(x,u).$$

$$T(u,x) = T(x,u)$$

$$= \frac{1}{N}\left[\prod_{i=0}^{N-1} (-1)^{b_i(x) \cdot b_{n-1-i}(x)}\right]$$

(or)

$$= \frac{1}{N}\left[(-1)^{\sum_{i=1}^{N-1} b_i(x) b_{n-1-i}(x)}\right]$$

Similarly Inverse Walsh Transform can be obtained.

$$f(x) = \sum_{u=0}^{N-1} W(u) \prod_{i=0}^{N-1} (-1)^{b_i(x) b_{n-1-i}(u)}.$$

(or)

$$f(x) = \sum_{u=0}^{N-1} W(u) (-1)^{\sum_{i=1}^{N-1} b_i(x) b_{n-1-i}(u)}.$$

Two Dimensional Walsh Transform can be written as

$$W(u,v) = \frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y) \prod_{i=0}^{N-1} (-1)^{b_i(x)}$$

$$W(u,v) = \frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y) \prod_{i=0}^{N-1} (-1)^{\left[b_i(x) b_{n-1-i}(u) + b_i(y) \cdot b_{n-1-i}(v)\right]}$$

$$\cancel{W(u,v) = \frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y) \prod_{i=0}^{N-1} (-1)^{[b_i]}}$$

$$W(u,v) = \frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y) (-1)^{\sum_{i=1}^{N-1}\left[b_i(x) b_{n-1-i}(u) + b_i(y) b_{n-1-i}(v)\right]}$$

Similarly 2-D Inverse Walsh Transform is given by

$$f(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} W(u,v) \prod_{i=0}^{N-1} (-1)^{\left[b_i(x) b_{n-1-i}(u) + b_i(y)(b_{n-1-i}(v))\right]}$$

$$f(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} W(u,v) (-1)^{\sum_{i=0}^{N-1}\left[b_i(x) b_{n-1-i}(u) + b_i(y) b_{n-1-i}(v)\right]}$$

⇒ PROPERTIES OF WALSH TRANSFORM :-

→ Walsh transform is real orthogonal and symmetric. i.e

$$W = W^* = W^T = W^{-1}$$

→ Walsh transform is a fast and implement sequency property.

→ Walsh transform contain the values ±1, so that it requires only additions and subtractions and no multiplications.

$$H = \begin{array}{c} \\ \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \end{array} \begin{array}{c} \text{Sign} \\ 0 \\ 3 \\ 1 \\ 2 \end{array}$$

→ Walsh matrix can be obtained by following sequency in sign changes.

$$W = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{array}{c} 0 \\ 1 \\ 2 \\ 3. \end{array}$$

Problem:

If $f(x) = \{1, 2, 0, 3\}$ apply walsh transform.

For two-dimensional

$$F = WfW^T$$
$$F = W \cdot fW$$

one dimensional.

$$F = Wf$$

$$F = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 0 \\ 3 \end{bmatrix}$$

$$F = \begin{bmatrix} 6 \\ 0 \\ 2 \\ -4 \end{bmatrix}$$

If $f(x) = \begin{bmatrix} 2 & 1 & 2 & 1 \\ 1 & 2 & 3 & 2 \\ 2 & 3 & 4 & 3 \\ 1 & 2 & 3 & 2 \end{bmatrix}$ Apply walsh transform.

$$F = WfW^T$$
$$= WfW. \quad \because W = W^T.$$

$$F = Wf$$

$$= \begin{bmatrix} 2 & 1 & 2 & 1 \\ 1 & 2 & 3 & 2 \\ 2 & 3 & 4 & 3 \\ 1 & 2 & 3 & 2 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} 6 & 0 & 0 & 0 \end{bmatrix}$$

$$= 6 \quad 7 \quad 8 \quad 7$$

$$\Rightarrow \begin{bmatrix} 2+1+2+1 & 1+2-3-2 & 2-3-4+3 & 1-2+3-2 \\ 2+1-2-1 & 1+2-3-2 & 2-3-4+3 & 1-2+3-2 \\ 2-1-2+1 & 1-2-3+2 & 2-3-4+3 & 1-2-3+2 \\ 2-1+2-1 & 1-2+3-2 & 2-3+4-3 & 1-2+3-2 \end{bmatrix}$$

$$\Rightarrow \begin{pmatrix} 6 & -2 & -2 & 0 \\ 0 & -2 & -2 & 0 \\ 0 & -2 & -2 & 0 \\ 2 & -2 & -2 & 0 \end{pmatrix}$$

⇒ HADAMAD TRANSFORM:-

→ It is one of the non sinusoidal transform.

→ It is useful in digital hardware implementation of image processing algorithm.

→ It is very faster when compare to sinusoidal transforms.

→ It is easy to stimulate but difficult to analyse.

→ It mainy finds its applications in image compression filtering and design of codes.

→ 1-D Hadamad transform is as follows

$$\left(H(u) = \frac{1}{N} \sum_{x=0}^{N-1} f(x) (-1)^{\sum_{i=1}} \prod_{i=0}^{N-1} \right)^{x}$$

$$H(u) = \frac{1}{N} \sum_{x=0}^{N-1} f(x) \prod_{i=0}^{N-1} (-1)^{b_i(x) b_i(u)}.$$

inverse 1-D Hadamad transform.

$$f(x) = \sum_{u=0}^{N-1} H(u) \prod_{i=0}^{N-1} (-1)^{b_i(x) b_i(u)}.$$

2-D:-

$$H(u,v) = \frac{1}{N} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \sum_{i=0}^{N-1} (-1)^{b_i(x) b_i(u) + b_i(y) b_i(v)}$$

inverse.

$$f(x,y) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} H(u,v) \prod_{i=0}^{N-1} (-1)^{b_i(x) b_i(u) + b_i(y) b_i(v)}$$

PROPERTIES OF HADAMAD TRANSFORM:- HT

→ HT is real, orthogonal and symmetric, i.e

$$H = H^{*} = H^{-1} = H^{T}.$$

→ Hadamad transform have very fast algorithm.

→ Hadamad can be implemented in terms of additions and subtractions, no multiplications are required (H.T contains only ±1 values).

→ H.T can be obtained from

$$H = \begin{bmatrix} H_{2N} & H_{2N} \\ H_{2N} & -H_{2N} \end{bmatrix}$$

2x2 H.T matrix is $H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$

4x4 H.T matrix is $H_4 = \begin{bmatrix} H_2 & H_2 \\ H_2 & -H_2 \end{bmatrix}$

8x8 H.T matrix is $H_8 = \begin{bmatrix} H_4 & H_4 \\ H_4 & -H_4 \end{bmatrix}$

one dimensional $F = H \cdot f$

Two dimensional $F = H \cdot f \cdot H^{T}$

$$= H \cdot f \cdot H.$$

Problem same as in walsh transform

⇒ DISCRETE COSINE TRANSFORM (DCT) :- (contains only Real terms)

* DCT helps to separate the image into parts of different importance (WRT visual image quality)

* DCT is similar to DFT, it transforms an image from spatial domain to frequency domain.

* DCT is used for image data compression. DFT → contains Real & complex

* 1-D DCT is defined as

$$c(u) = \alpha(u) = \sum_{x=0}^{N-1} f(x) \cos\left[\frac{(2x+1)u\pi}{2N}\right] \text{ for } u = 0,1,2\cdots(N-1)$$

inverse DCT is obtained as

$$f(x) = \sum_{u=0}^{N-1} \alpha(u) C(u) \cos\left[\frac{(2x+1)u\pi}{2N}\right]$$

$$\text{where } \alpha(u) = \begin{cases} \sqrt{\frac{1}{N}}, & \text{for } u=0 \\ \sqrt{\frac{2}{N}}, & 1 \le u \le (N-1) \end{cases}$$

Two dimensional DCT is defined as

$$c(u) = \alpha(u)\alpha(v) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{(2x+1)u\pi}{2N}\right] \cdot \cos\left[\frac{(2y+1)u\pi}{2N}\right] \text{ for } u,v = 0,1,2\cdots(N-1)$$

inverse DCT is obtained as

$$f(x,y) = \cancel{\alpha(u)\alpha(v)} \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} \alpha(u)\alpha(v) \cdot C(u,v) \cos\left[\frac{(2x+1)u\pi}{2N}\right] \cos\left(\frac{(2y+1)v\pi}{2N}\right)$$

$$\alpha(v) = \alpha(u) = \begin{cases} \sqrt{\frac{1}{N}} & \text{for } u=0,\ 0 \le v \le (N-1) \\ \sqrt{\frac{2}{N}} & 1 \le u \le (N-1) \end{cases}$$

Properties of DCT :-

↳ DCT is Real and orthogonal (Not symmetric) i.e $C = C^T$

↳ DCT kernels are separable.

↳ 2-D forward and reverse transform can be computed by successive application of 1D DCT algorithm.

↳ DCT can be directly obtained from FFT.

one dimensional :- $f = c \cdot f$

two " :- $f = c \cdot f \cdot c^T$.

Cosine matrix can be obtained $C = \begin{cases} \sqrt{\frac{1}{N}} & u=0,\ 0 \le v \le (N-1) \\ \sqrt{\frac{2}{N}} \cos\left[\frac{(2v+1)\pi u}{2N}\right] & 1 \le u \le (N-1),\ 0 \le v \le (N-1) \end{cases}$

Problem :-

① find 4x4 cosine matrix for N = 4

$$C(u,v) = \begin{bmatrix} c(0,0)^{0.5} & c(0,1)^{0.5} & c(0,2)^{0.5} & c(0,3)^{0.5} \\ c(1,0)^{0.65} & c(1,1)^{0.27} & c(1,2)^{0.27} & c(1,3)^{0.65} \\ c(2,0)^{0.5} & c(2,1)^{0.5} & c(2,2)^{0.5} & c(2,3)^{0.5} \\ c(3,0)^{0.27} & c(3,1)^{0.65} & c(3,2)^{0.65} & c(3,3)^{0.27} \end{bmatrix}$$

$\uparrow N=0$

$c = \sqrt{\frac{1}{N}} = \frac{1}{2} = 0.5$

$c = \sqrt{\frac{2}{N}} \cos \frac{(2v+1)\pi u}{2N}$

↓ $N \ne 0$

RRO

SLANT TRANSFORM:

- It is used for img coding (Encoding & Decoding)
- It produces sawtooth waveforms.
- slant Transform is an orthogonal transform which produces discrete sawtooth waveforms (or) slant basis vectors.
- It is specially designed for image coding. It has the sequence property
- It has a very fast computational algorithm.
- slant transform of order NxN is given by,

$$S_N = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ a_N & b_N & & -a_N & b_N & \\ 0 & I_{(N/2)-2} & 0 & & & I_{(N/2)-2} \\ 0 & 1 & 0 & 0 & -1 & 0 \\ -b_N & a_N & & -b_N & a_N & \\ 0 & \vdots & I_{(N/2)-2} & 0 & & -I_{(N/2)-2} \end{bmatrix}$$

where

I is an Identity matrix of order mxm.

2x2 slant transformation matrix is given by

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$$S_2 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

4x4 slant transformation matrix is given by

$$S_4 = \begin{bmatrix} 1 & 0 & 1 & 0 \\ a & b & -a & b \\ 0 & 1 & 0 & -1 \\ -b & a & b & a \end{bmatrix}\begin{bmatrix} S_2 & 0 \\ 0 & S_2 \end{bmatrix}$$

where

$$a = \left[\frac{3N^2}{4(N^2-1)}\right]^{1/2} ; \quad b = \left[\frac{N^2-4}{4(N^2-1)}\right]^{1/2}$$

For N=4

$$S_4 = \frac{1}{\sqrt{4}}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 3/\sqrt{5} & 1/\sqrt{5} & -1/\sqrt{5} & -3/\sqrt{5} \\ 1 & -1 & -1 & -1 \\ 1/\sqrt{5} & -3/\sqrt{5} & 3/\sqrt{5} & -1/\sqrt{5} \end{bmatrix}$$

Properties of slant transform:-

* slant transform is real & orthogonal i.e $S = S^T$
* It is very fast algorithm, can be implemented in log operations
* The img obtained in this transform is rated as ~~very~~ excellent

for 1-D = Sf

2D = $S \cdot f \cdot S^T$

HAAR TRANSFORM:-

* Haar transform is a very simple wavelet transform.

* Haar transform is based on a class of orthogonal matrices.
* whose elements are -1, +1, 0, multiply by the powers of $\sqrt{2}$
* Haar transform is computationally efficient as the transform of N point vector requires only $2 \times N-1$ additions and N multiplications.
* 2x2 Haar transformation matrix is given by

$$H_2 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

* 4x4 Haar transformation matrix is given by

$$\cancel{H_4 = \begin{matrix} 1 & 1 & 1 & 1 \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & -1 & -1 \end{matrix}} \qquad H_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$$

⇒ HOTELLING TRANSFORM:-

* Hotelling transform is also known as KL transform (or) Eigen vector transform.
* IN DCT (or) DFT we have fixed Matix, but in KL Transform the transformation matrix depends upon the image.
* It is a statistical based method used for Image.

Steps to perform KL Transform:-

* Find x vector.
* Find the mean ; $\mu = \frac{1}{N}\sum_{i=0}^{N-1} x_i$
* Find the co-variance vector, $c_x = \frac{1}{N}\sum_{i=0}^{N-1} (x_i - \mu_x)(x_i - \mu_x)^T$

* find the eigen values $|C_x - \lambda I| = 0$

* find the eigen vector for respective eigen value.

$$C_x z = \lambda z.$$

* Transformation matrix, $A = \begin{bmatrix} c_0^T \\ c_1^T \\ \vdots \\ c_N^T \end{bmatrix}$

where c_0^T is the eigen vector for highest value of λ

i.e. $\lambda_0 > \lambda_1 > \lambda_2 > \dots \lambda_n$.

* KL Transform, $Y = \lambda [x - \mu_x]$

⇒ Algorithm for Haar Transform:-

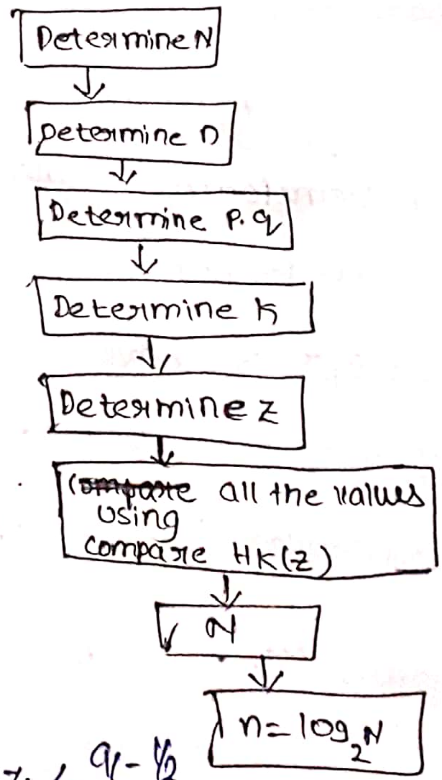
* Determine the order of N of haar basis
* Determining n where $n = \log_2 N$
* Determine p & q (i) $0 \le p \le n-1$

If $p = 0$, $q = 0$ (or) 1

$p \neq 0$, $1 \le q \le 2^p$

* Determine K

$$K = 2^p + q - 1$$



* Determine Z

$$Z \to [0,1) \to \{0/N;\ 1/N \dots N-1/N\}$$

* If $K = 0$

$$H_K(Z) = 1/\sqrt{N}$$

If $K \neq 0$

$$H_K(Z) = H_{pq}(Z) = \frac{1}{\sqrt{N}} \begin{cases} 2^{p/2}, & \frac{q-1}{2^p} \le Z < \frac{q-1/2}{2^p} \\ -2^{p/2}, & \frac{q-1/2}{2^p} \le Z < q^{p/2} \\ 0, & \text{otherwise} \end{cases}$$

UNIT-II

IMAGE ENHANCEMENT

IMAGE ENHANCEMENT:-

It is to process an image so that the result is more suitable than the original image for specific applications.

Image enhancement is brodly classified into 2 types

(1) spatial Domain Techniques

(2) Frequency Domain Techniques.

- spatial Domain refers to the direct manipulation of pixels in an image.
- Frequency Domain refers to modification of the fourier transform of the image.

IMAGE ENHANCEMENT IN SPATIAL DOMAIN:

The operations carried in spatial domain are of 3 types

(1) point operation:- Each pixel is modified by an equation that is not dependent on other pixel values.

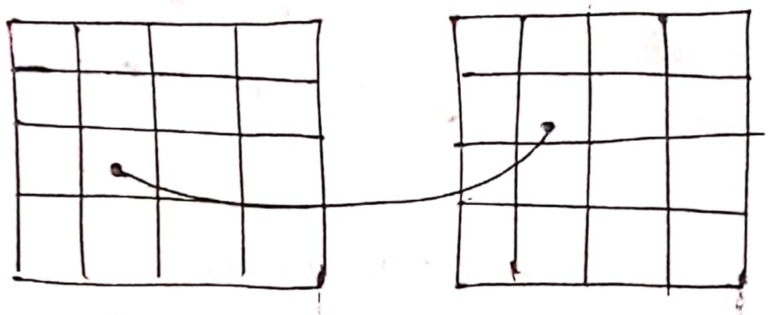
$$g(x,y) = T\left[f(x,y)\right]$$

Where,

$f(x,y)$ = input img

$g(x,y)$ = process enhanced img.

In gray level transformation the function can be return as $s = T(r)$



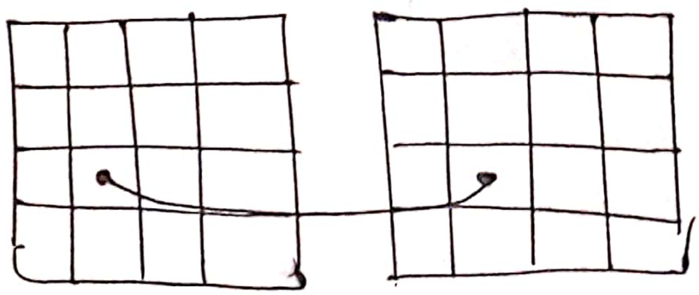
(2) Mask operation:-

- Each pixel is modified according to the values in Neighbourhood.

Ex:- spatial Low pass filtering.

In symmetric Masks, origin is the center pixel position

In Non symmetric Masks, origin may be any pixel positions.



(3) Global operation:-

In this operation all the pixel values are taken into consideration.

⇒ ENHANCEMENT IN POINT PROCESSING:-

1. contrast sketching
2. Graylevel slicing
3. Bitplane slicing
4. Image Negative

} piecewise Linear transformation functions.

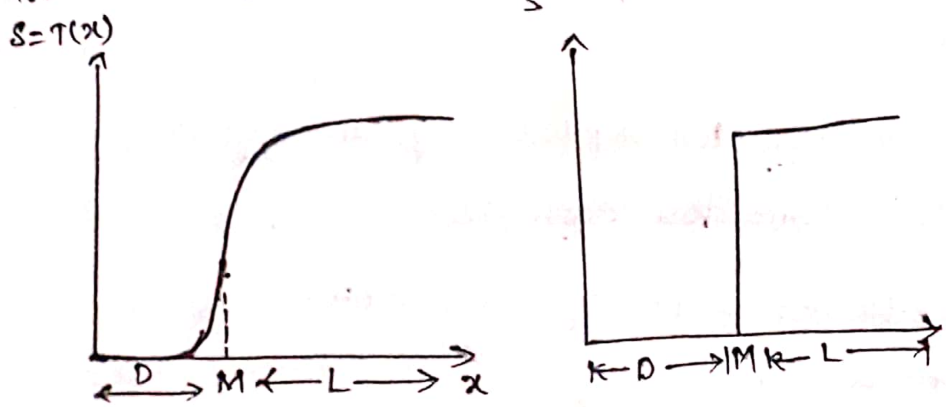
5. Log Transformation
6. power law Transformation

} Non-linear transformation.

7. Histogram processing

1. contrast sketching:

- Low contrast Images can result from poor illumination, lack of dynamic range in image sensor, wrong setting of lens during image acquisition.
- contrast sketching increases the dynamic range of pixels in the image being ~~to~~ processed.



- This transformation produces an image of higher contrast than original image by darkening the levels below 'M' & brightening the levels above 'M'.

Scanned with CamScanner

• T(x) produces a 2-level binary image by using a thresholding function 'M'

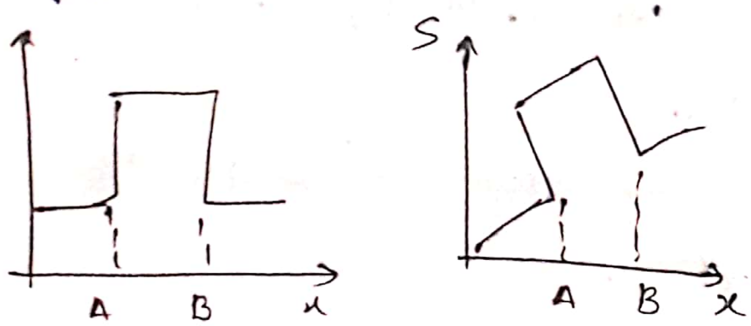
(2) Gray level slicing:-

• Gray level slicing is used when a specific range of gray levels are to be highlighted.

There are 2 ways to achieve:

(i) It displays high values for the range of interest & low values in the other areas. Background is not preserved.

(ii) It displays high values for the range of interest & the other values will have the original gray levels. Background is preserved.



(3) Bit-plane slicing:-

• Bit plane slicing is an method for representing an img with 1 or more bits of the byte used for each pixel.

One can use only MSB to represent the pixel which reduces the original gray level to binary img.

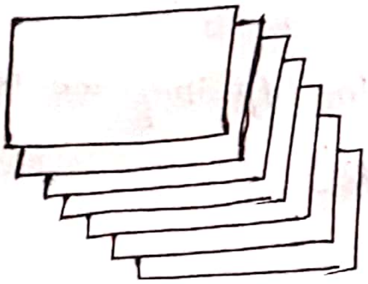
• Let each pixel in an img is represented by 8 bits. Imagine that image is composed of 8 1-bit planes ranging from bit plane (0 LSB) to bit plane (7) (MSB)

i.e plane 0 contains all lower order bits & plane 7 contains all higher order bits.

- The main goal of bit-plane slicing:

1. converting a graylevel img to binary level img.
2. Representing an img with fewer bits & compressing img to smaller size.
3. Enhancing the img by focusing.

Bit plane 7 (MSB)



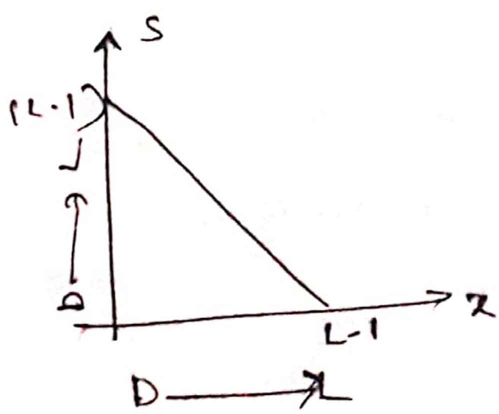
Bit plane 0 (LSB)

(4) Image Negatives:

The negative of the img with gray levels in the range [0, L-1] is obtained by using the negative transformation.

$$s = L-1-r.$$

Reversing the intensity levels of an image in this manner produces the equivalent photographic negative.

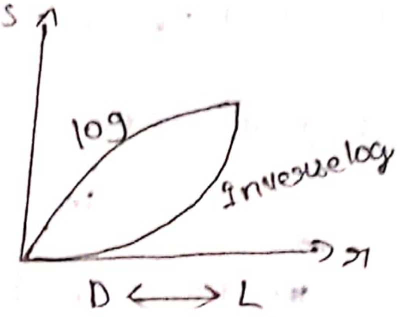


(5) Log Transformation:-

The general form of log transformation is given by

$$s = c\log(1+r)$$

where, c = constant

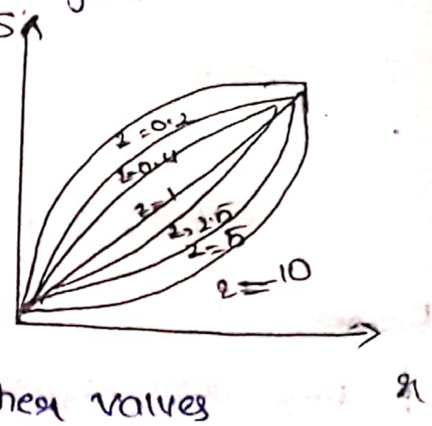


- The log transformation maps a narrow range of low gray level values in the i/p image into wider range of o/p levels (spreads the lower gray levels)
- The Inverse log transformation is the reverse of log i.e, narrow range of high gray level values in the i/p img are widened in the o/p (spreads the high gray level values).

(6) power law Transformation:-

The general form of Powerlaw Transformation is given by $s = cr^{\gamma}$.

where, c & r are constants



- power law curves with fractional values of γ maps a narrow range of dark i/p values into wider range of o/p values, with opposite being true for higher values of i/p levels.

If $r<1$ → image appears to be dark.

If $r>1$ → Image appears to be bright.

Scanned with CamScanner

⇒ ENHANCEMENT BY HISTOGRAM PROCESSING:

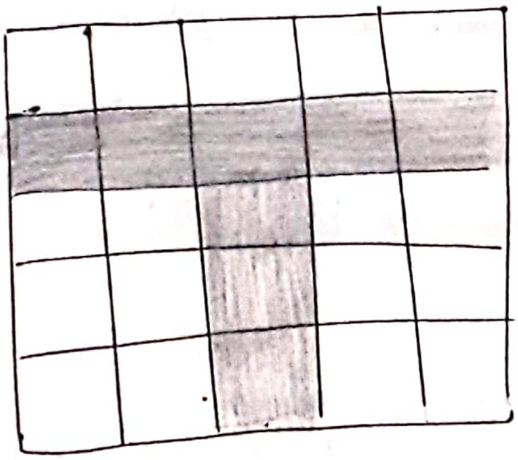
1) Given a digital image with gray levels 0 to L, the histogram of the image is a representation of frequency of occurance of each gray level in the image.

Histogram is used as a tool to know the number gray levels in the pixels of an image.

This is effectively used for image enhancement.

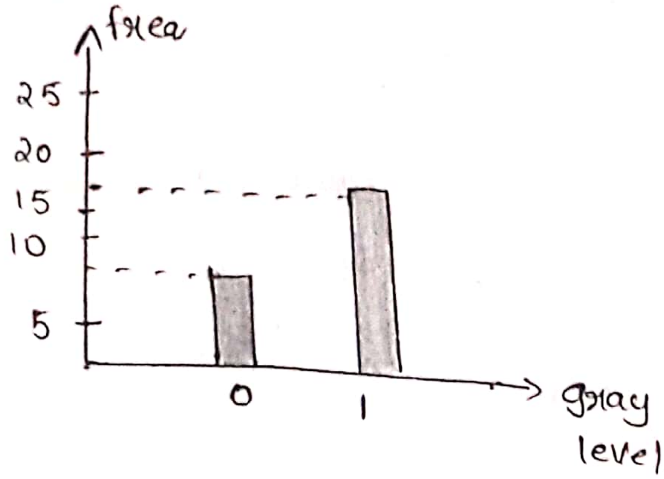
Representation of a histogram:

Histogram can be represented either by table or graphically.



Gray levels	(frecy of occurance) No. of pixels in each gray level
0	8
1	17

Graphical Representation:



The histogram of a digital image with gray level $0, L-1$ in the discrete form is given by

$$H(r_k) = n_k$$

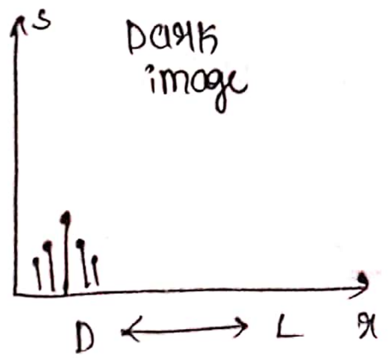
Where r_k is k^{th} gray level

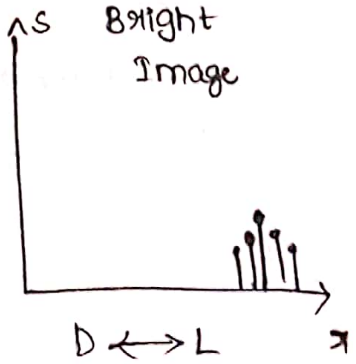
n_k is number of pixels in the image with the gray level r_k

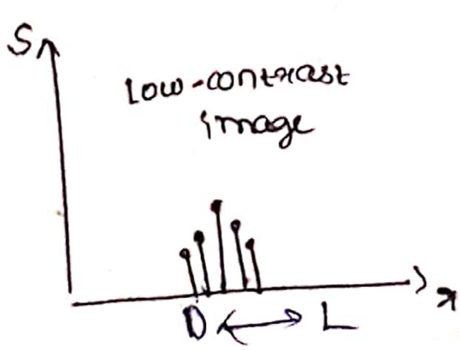
A normalised histogram is given by $p(r_k) = \frac{n_k}{n}$

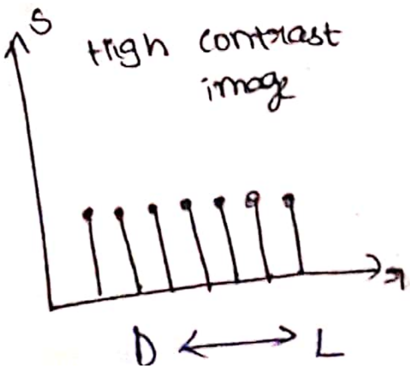
where, $p(r_k)$ is the probability of occurance with gray level r_k.

The histogram plots are as shown









↳ In the dark image, the components of histogram are concentrated on the lower side of gray scale.

↳ In the bright image, the histogram components are concentrated on the higher side of gray scale.

↳ The histogram of the low contrast image will be narrow and centered towards the middle of gray scale.

↳ The histogram of a high contrast image covers a broad range of gray levels.

↳ Histogram processing can be done in the following ways:

(1) Histogram Equalization.

(2) Histogram manipulation | matching | specification.

(1) Histogram Equalization:

↳ Equalization is a process that attempts to spread out the gray levels in the image so that they are evenly distributed across the range.

↳ It is a technique where the histogram of the resultant image is as flat as possible.

↳ Let there is a continuous function with 'r' gray levels of the image to be enhanced. The range of 'r' is [0,1], The transformation function is given by $s = T(r)$

↳ Let $P_s(s)$ and $P_r(r)$ denote the PDF's of s and r respectively.

$P_s(s)$ is given by,

$$P_s(s) = P_r(r) \left| \frac{\partial r}{\partial s} \right| \longrightarrow ①$$

consider $s = T(r) = (L-1) \int_0^r P_r(\omega) \cdot d\omega$.

This is known as CDF (cumulative distributive function).

Then,

$$\frac{\partial s}{\partial r} = \frac{\partial}{\partial r} (L-1) \int_0^r \cdot P_r(\omega)\, d\omega$$

$$\frac{\partial s}{\partial r} = (L-1)\ P_r(r)$$

substituting in EQ①

$$P_s(s) = \frac{1}{L-1}$$

If a monochrome image is considered

$P_s(s) = 1$. Thus the PDF of 's' is uniform.

procedure to Perform histogram equalisation:

1) Find the running sums of the histogram values.

2) Normalise the values from step-1 by dividing with the total number of pixels.

3) Multiply the values from step-2 by the maximum gray level value and round it off.

4) Map the gray levels from step-3 using one to one correspondence.

① perform histogram equalisation for the given image.

$$\begin{bmatrix} 4 & 4 & 4 & 4 & 4 \\ 3 & 4 & 5 & 4 & 3 \\ 3 & 5 & 5 & 5 & 3 \\ 3 & 4 & 5 & 4 & 3 \\ 4 & 4 & 4 & 4 & 4 \end{bmatrix}$$

↳ The maximum value is found to be 5, we need minimum of 3 bits to represent 5. (4 2 1) → code. So there are 8 possible gray levels, 0 to 7.

↳ Histogram of the given input image:

Graylevels	0	1	2	3	4	5	6	7
No. of pixels in each gray level	0	0	0	6	14	5	0	0

$(2^3 \to 8)$. (No of 0)

Step-1:- compute the running sums of the histogram values.

The running sums of histogram values is known as cummulative frequency distribution.

Gray levels	0	1	2	3	4	5	6	7
No. of pixels in each gray level	0	0	0	6	14	5	0	0
Running sums.	0	0	0	6	20	25	25	25.

Step-2:

Divide the running sums obtained in step 1 with total number of pixels, in these case total Number of pixels are 25.

Gray level	0	1	2	3	4	5	6	7
No. of pixels in each gray level	0	0	0	6	14	5	0	0
Running sums	0	0	0	6	20	25	25	25
$\frac{\text{Running sum}}{\text{Total no of pixels}}$	$0/25=0$	$0/25=0$	$0/25=0$	$6/25$ 0.24	$\frac{20}{25}$ 0.8	1	1	1

Step3:-

Multiply the values from step2 by max value and round it of.

Gray levels	0	1	2	3	4	5	6	7
No. of pixels in each gray level.	0	0	0	6	14	5	0	0
Running sums	0	0	0	6	20	25	25	25
$\frac{\text{Running sum}}{\text{Total no of pixels}}$	0	0	0	0.24	0.8	1	1	1
Multiply with 7	0	0	0	2	6	7	7	7

(No of gray levels = 7)

Step4:-

Mapping of gray levels with 1 to 1 correspondence.

Original gray level	Histogram Equalized values.
0	0
1	0
2	0
3	2
4	6
5	7
6	7
7	7

∴ The histogram equalised value is :

$$\begin{bmatrix} 4 & 4 & 4 & 4 & 4 \\ 3 & 4 & 5 & 4 & 3 \\ 3 & 5 & 5 & 5 & 3 \\ 3 & 4 & 5 & 4 & 3 \\ 4 & 4 & 4 & 4 & 4 \end{bmatrix} \rightarrow \begin{bmatrix} 6 & 6 & 6 & 6 & 6 \\ 2 & 6 & 7 & 6 & 2 \\ 2 & 7 & 7 & 7 & 2 \\ 2 & 6 & 7 & 6 & 2 \\ 6 & 6 & 6 & 6 & 6 \end{bmatrix}$$

(2) Histogram matching:-

↳ It modifies the histogram of one image so that it resembles as the histogram of the seccond image.

↳ It requires more computations when compared to equalisation.

↳ It allows interactive image enhancement.

↳ Mathematically

$$\underset{\text{Histogram}}{H(Z)} = \int_0^{r} P_r(w) \cdot dw$$

$$= S$$

$$Z = H^{-1}(S)$$ ↱ Processed image.

⇒ LOCAL ENHANCEMENT OR NEIGHBOURHOOD OPERATION:

↳ In neighbourhood operation the pixels in an image are modified based on some function of pixels in their neighbourhood.

↳ Linear spacial filtering is a process of convolving a mask with an image.

↳ The filter masks are known as convolutional masks or convolutional kernels.

Spatial domain filters:

↳ Spatial filtering involves passing a weighted mask over the image and replacing the original ~~pi~~ image pixel value corresponding to the center of kernel with the some of original pixel values in the region corresponding to kernel multiplied by kernel weights.

w1	w2	w3
w4	w5	w6
w7	w8	w9

Weighted mask

I_1	I_2	I_3
I_4	I_5	I_6
I_7	I_8	I_9

I/p image.

~~spatial~~ spatial domain filter output image is given by $O/P = \frac{1}{N}\sum_{i=1}^{N} w_i I_i$

(1) MEAN FILTER / AVERAGING / LOW PASS FILTERING:-

- Mean filter replaces each pixel by the avg of all the values in the local neighbourhood.
- In spatial averaging operation. each pixel is replaced by the weighted avg of neighbourhood pixels.
- LPF weighted mask (3x3) is given by, $\frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

$$LPF\ O/P = \frac{1}{N}\sum_{i=1}^{N} w_i I_i$$

~~Problem~~:-

Similarly 5x5 LPF MASK can be written as

$$\frac{1}{25} \times \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

Problem:

Given the i/p image

1	1	1
1	0	1
1	1	1

Find the o/p using mean filter.

$$\frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\frac{1}{9}\left[1+1+1+1+0+1+1+1+1\right] = 8/9 = 0.8.$$

O/P image ⇒

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix} \longrightarrow \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0.8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Limitations of averaging filter:-

- It leads to blurring of an image.
- If the averaging operation is applied to an image ~~corrme~~ corrupted by noise ~~is~~. Then the noise is attenuated but not Removed.

(2) **HIGHPASS FILTER:-**

- HPF is also known as Image sharpening.
- The main aim of HPF is to enhance the high frequency components i.e ~~find~~ fine details of an image
- HPF mask (3x3) is $\frac{1}{9}\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$

Similarly (5X5) HPF mask is

$$\frac{1}{25}\begin{bmatrix} -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & 24 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 \end{bmatrix}$$

Problem:-

Given, The input image is $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ Find the output using 3x3 HPF Mask.

$$\frac{1}{9}\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix} = \frac{1}{9}\begin{bmatrix} -1 -1 -1 -1 + 0 -1 -1 -1 -1 \end{bmatrix}$$

$$= \frac{-8}{9} = -0.8.$$

1	1	1
1	0	1
1	1	1

$\rightarrow$

1	1	1
1	0.8	1
1	1	1

(3) WEIGHTED AVERAGING FILTER:-

The mask for weighted averaging filter is

$$\frac{1}{16} \times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

(4) BARTLET FILTER:-

↳ It is a triangular shaped filter in spatial domain.

↳ It is obtained by convolving two 3x3 box filters.

↳ 3x3 box filter is given by $\frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

↳ Bartlet window mask is given by,

$$\frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} * \frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

(5) MEDIAN FILTER:- These are statistical non-linear filters used in spatial domain.

↳ It smoothens the img by utilising the median of neighbourhood

↳ The following tasks are performed to find each pixel value in the processing image.

(i) All the pixel values in the neighbourhood of the original image which are identified by the mask or

Sorted either in ascending or descending order.

↳ The median of the sorted value is computed and is choosen as the pixel value in the processed image.

Problem:

compute the median value of the marked pixel using 3x3 Mask.

1	5	7
2	4	6
3	2	1

First, all the pixel values are to be arranged in ascending order

1, 1, 2, 2, 3, 4, 5, 6, 7

Median value of the ordered pixel is given by

$\cancel{1}, \cancel{1}, \cancel{2}, \cancel{2}, 3, \cancel{4}, \cancel{5}, \cancel{6}, \cancel{7}$

Median = 3

After median filtering the o/p image obtained is

1	5	7
2	4	6
3	2	1

→

1	5	7
2	3	6
3	2	1

↳ Median filter is mainly used to minimize salt & pepper noise

↳ salt is the maximum grey level value (1)
↳ White.

and the pepper is minimum grey level value 0
↓
black.

(6) HIGH BOOST FILTER:- It is also known as the high frequency emphasis filter.

↳ A high boost is used to retain sum of the low frequency components to aid in the interpretation of an image.

↳ High boost is obtained from, High Boost = $A \times f(x,y)$ − Lowpass Img

where A is the gain factor. $f(x,y)$ is i/p image

↳ Adding & subtracting one with gain factor,

$$\text{High Boost} = (A-1+1) \times f(x,y) - LP.$$

$$= (A-1) \times f(x,y) + f(x,y) - LP.$$

We know that, Original img = LP image + Highpass image.

High boost filter can be written as,

$$\boxed{\text{High boost} = (A-1) \times f(x,y) + HP}$$

(or)

$$\boxed{HB = OI + HPI}$$

⇒ IMAGE ENHACEMENT USING FREQUENCY DOMAIN:

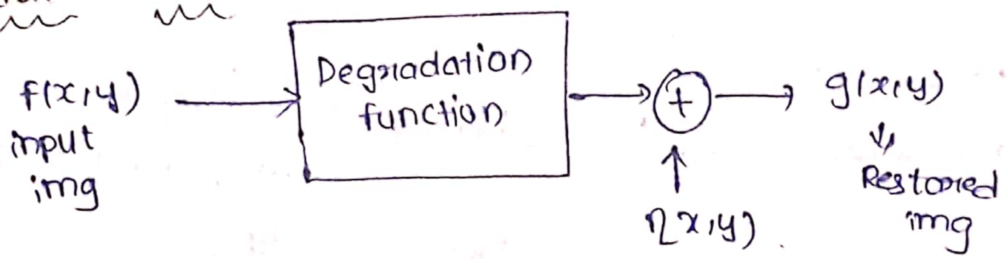
UNIT-III

IMAGE RESTORATION

↓ Restoring the image.
(Get back of original image)

↳ The process of Retreiving of image
Restoration depends on degration of image.

⇒ **Degradation model:**



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

(f → original, h → Degradation, η → noise)

$G(U,V) = F(U,V) \cdot H(U,V) + N(U,V)$

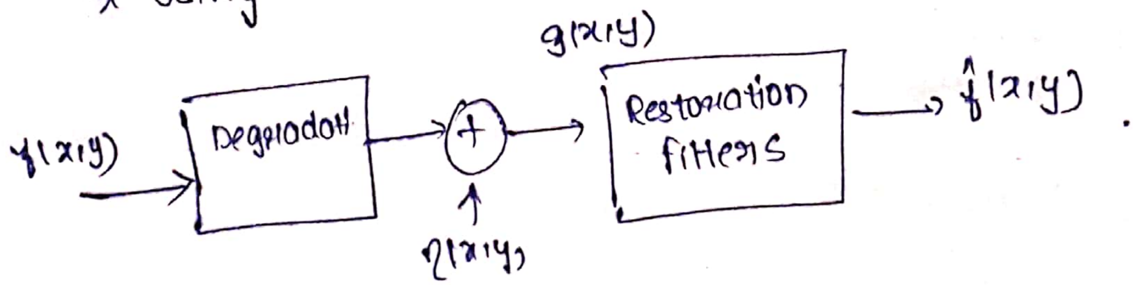
↓ Multiplication in frequency domain

O/P of image restoration:

$$\boxed{F(U,V) = \frac{G(U,V)}{H(U,V)} - \frac{N(U,V)}{H(U,V)}}$$

↓ Restore original img back.

↳ inorder to ~~ubta~~ obtain original signal back we using i/p signal degradation function



~~g(x,y)~~ ≠

⇒ Types of Restoration:-

Depending upon knowledge about degradation function

they are :

- (i) complete knowledge of degradation function
- (ii) partial " " " "
- (iii) No " " " "

(i) uses inverse filtering
(ii) Wiener filtering
(iii) Blind Restoration. (X) (blindly convolving degradation funcn with (IR) i/p)

⇒ Algebraic approach for image restoration:

↳ mathematical values.

2 Approaches for (IR) :

(i) unconstrained

(ii) constrained → have conditions

(1) unconstrained :

↳ (i) It doesn't have any conditions / no constraints

↳ $G(U,V) = F(U,V) \cdot H(U,V) + N(U,V)$

in vector form the above EQ is

$g = Hf + n$ → noise
(H → degradation, f ↳ i/p image)

⇓

img Restoration (noise = 0)

$n = g - Hf$.

Norm of the vector
$$\|n\|^2 = n^T . n$$

- Apply normalisation on b.s

$$\|n\hat{f}\|^2 = \|g - H\hat{f}\|^2.$$

$$\frac{\partial J(\hat{f})}{\partial \hat{f}} = 0 \qquad J(\hat{f}) \rightarrow \text{Type of constrains}$$
We are considering

$J(\hat{f}) = \|g - H\hat{f}\|^2$ (for unconstrained)

$$\frac{\partial}{\partial \hat{f}} \|[g - H\hat{f}]\|^2 = 0 \quad \hookrightarrow \|g - H\hat{f}\|^2 = (g - H\hat{f})^T (g - H\hat{f})$$
finding estimate of an img

By diff, $-2H^T(g - H\hat{f}) = 0$

$$\cancel{-2} H^T g = \cancel{-2} H^T \hat{f} H$$
$\rightarrow$ estimate of org signal
$$\hat{f} = \frac{1}{Hg} \cdot g$$

Estimate of image can be obtained as

$\boxed{\hat{f} = H^{-1} . g}$ //inverse filtering equation.

(2) constrained: (will have some conditions)
$\rightarrow$ Type of noise that is occured on the img.
$Q\hat{f} \rightarrow$ is a ~~line const~~ condition in the form of linear operation in the form of constraint that is added to an image.

Q= linear operator.

$$\frac{\partial J(\hat{f})}{\partial \hat{f}} = 0$$

$$J(\hat{f}) = \alpha \| g - H\hat{f} \|^2 + \| Q\hat{f} \|^2$$

α = lagranges multiplier.

$$\frac{\partial}{\partial \hat{f}} \left[\| Q\hat{f} \|^2 + \alpha \| [g - H\hat{f}] \|^2 \right] = 0$$

$$2Q^T Q\hat{f} - 2\alpha H^T (g - H\hat{f}) = 0$$

$$2Q^T Q\hat{f} - 2\alpha H^T g + 2\alpha H^T H\hat{f} = 0$$

$$\hat{f}\,[\cancel{2}Q^T Q + \cancel{2}\alpha H^T H] = \cancel{2}\alpha H^T g$$

$$\hat{f}\,[Q^T Q + \alpha H^T H] = \alpha H^T g$$

$$\hat{f}\left[\frac{1}{\alpha} Q^T Q + H^T H\right] = H^T g$$

$$\hat{f}\,\cancel{[H^T H + \gamma Q^T Q]^{-1}} =$$

$$\hat{f} = \left[H^T H + \gamma Q^T Q \right]^{-1} \cdot H^T g$$

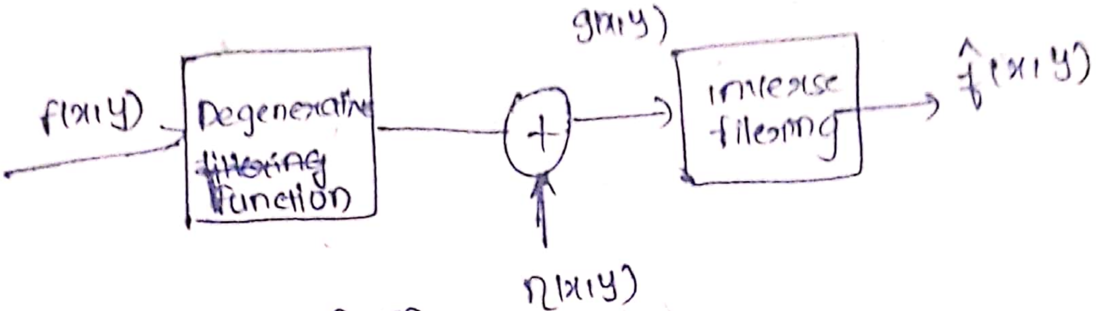
where, $\gamma = \frac{1}{\alpha}$

(i) INVERSE FILTERING:

WKT

$$F(U,V) = \frac{G(U,V)}{H(U,V)} = \frac{N(U,V)}{H(U,V)}$$ [in exam this eq should be from starting]

; unconstrained approach derivation we will get $\boxed{\hat{f} = H^{-1} g}$



~~We cannot perform~~

The disadvantage of inverse filtering is it is impossible to obtain the ~~forie~~ fourier transform of noise in all the cases to avoid this we are going to wiener filter

→ obtain e^2 error. ↑ constrained approach.

(ii) Minimum mean square Error filter / Wiener filter:-

* Square of signal is Expected value of original signal from estimated signal

Base Equation is, → obtain in denominator

$$\hat{f} = [H^T H + \gamma Q^T Q]^{-1} \cdot H^T g.$$ (added with psp, i/p img with noise).

W.K.T $|H(u,v)|^2 = H^*(u,v)\, H(u,v)$. → ①

$H^T H$ can be written by using EQ ①

$Q^T Q$ obtained as noise.

$$e^2 = E\{f(x) - \hat{f}(x)\}^2$$

$$= \left[\frac{H^*(u,v) \cdot S_f(u,v)}{|H(u,v)|^2 \cdot S_f(u,v) + S_n(u,v)}\right] G(u,v)$$

$$= \left[\frac{1}{H(u,v)} \cdot \frac{|H(u,v)|^2 S_f(u,v)}{|H(u,v)|^2 S_f(u,v) + S_n(u,v)}\right] G(u,v)$$

$$\boxed{\hat{F}(u,v) = \left[\frac{1}{H(u,v)} \cdot \frac{|H(u,v)|^2}{|H(u,v)|^2 + K}\right] G(u,v)}$$

$$K = \frac{S_n(u,v)}{S_f(u,v)}$$

where

$H(u,v)$ is Degradation function

$H^*(u,v)$ is complex conjugate of degration function.

K = A specific constant which is Equal to,

$$K = \frac{S_n(u,v)}{S_f(u,v)}$$

$S_f(u,v)$ and $S_n(u,v)$ are the power spectrums of undegraded (i/p) image and noise respectively.

The disadvantage of weiner filter is, we need to know the power spectrums of undegraded img and noise.

⇒ Constrained least square filtering:

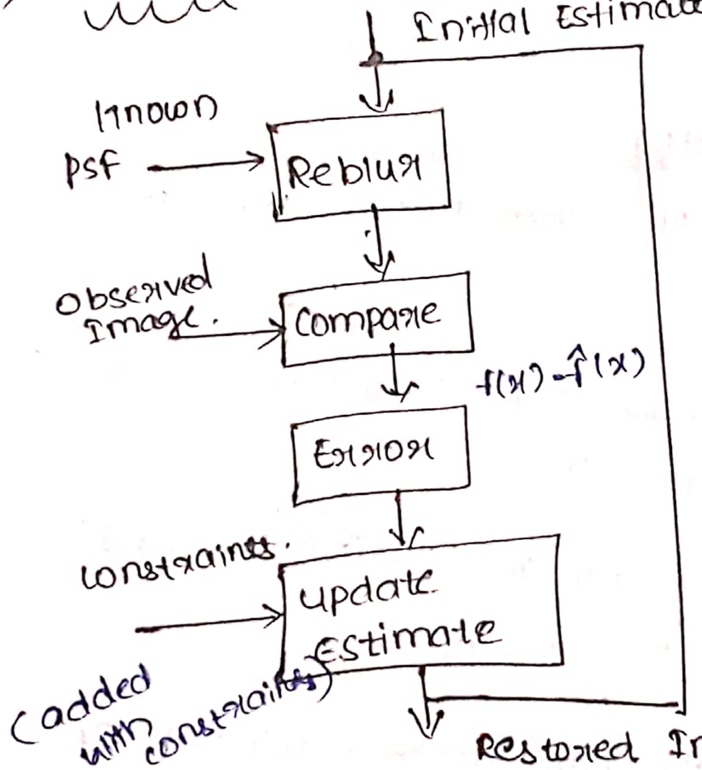
in order to avoid the dis of the weiner filter. This filtering method requires only the knowledge of mean and variance of noise which can be usually calculated from the given undegraded img, considered as the advantage for this filter.

$$\hat{F}(u,v) = \left[\frac{H^*(u,v)}{|H(u,v)|^2 + \gamma\, |P(u,v)|^2}\right] G(u,v).$$

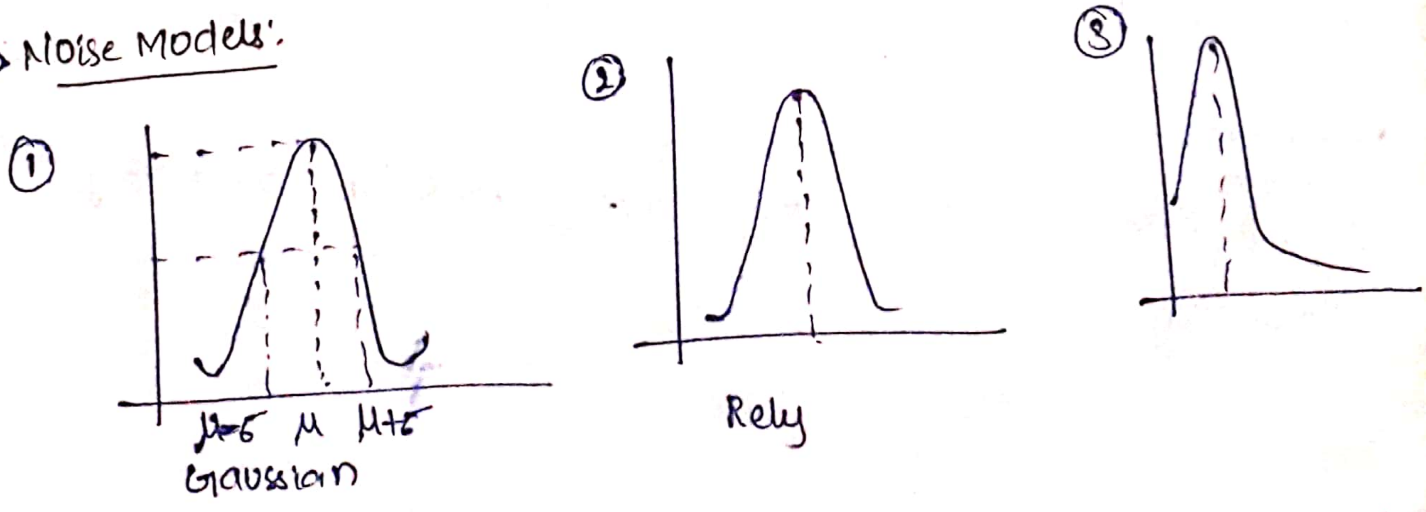
$P(u,v)$ = Fourier transform of linear operator.

γ is the operator that must be adjusted so that the constraint is satisfied.

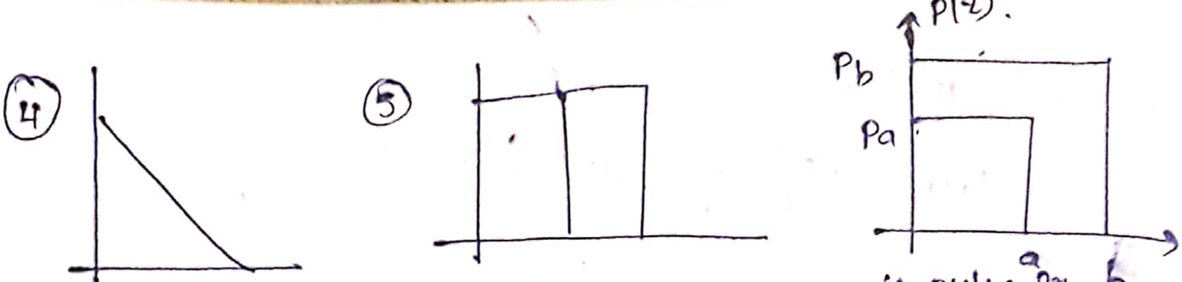
⇒ ITERATIVE RESTORATION :- → repeatedly the process is continued untill o/p of restoration is same as that of the i/p.



⇒ Noise Models:



④ ⑤



exponential noise. uniform noise impulse or salt & pepper noise

→ fig (a) ←

Iterative Restoration:- (10 mk).

In interative method, iterations are given by solving the least square solutions iteratively instead of directly.

The error metric is given by,

$$e = \|g - Hf\|$$

$$e = (g - Hf)^T (g - Hf)$$

Taking partial derivative of error metric WRT image is given by $\frac{\partial e}{\partial f} = -2H^T(g - Hf)$

The iterative img restoration procedure starts with initial estimate of original img.

It then compares the observed img with the blurred img and error is used to update the estimate.

The iterative restoration algorithm can be terminated if all the specific conditions are met.

Noise models:-

↳ In DIP. noise may occur either during acquisition or during transmission.

↳ During img aquisition due to misplacement of lengths img get blurred and leads to noise.

↳ During transmission interferences produces noise in the images.

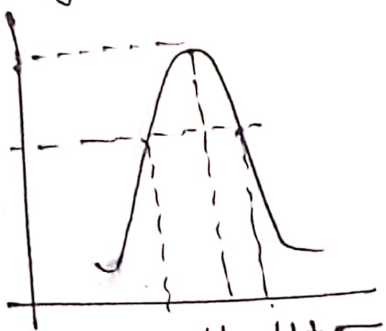
↳ The following are the diff types of noises that may occur in images

fig(a)

(1) Gaussian Noise:-

The PDF of Gaussian noise is given by

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



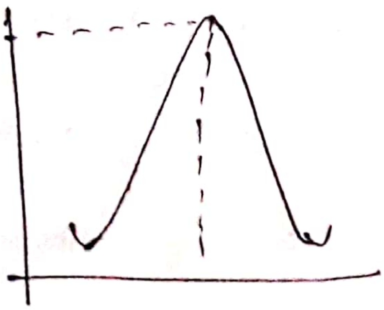
where m = Mean

σ^2 = Variance.

(2) Rayleigh Noise:-

The PDF of Rayleigh Noise is given by

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



Where,

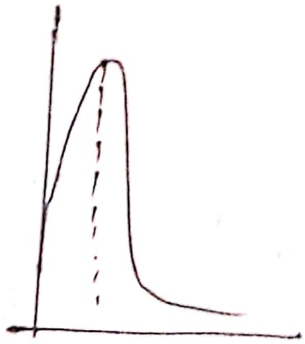
$$m = a + \sqrt{\frac{\pi b}{4}}$$

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

(3) Gamma Noise:

The PDF of gamma Noise can be given as:

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



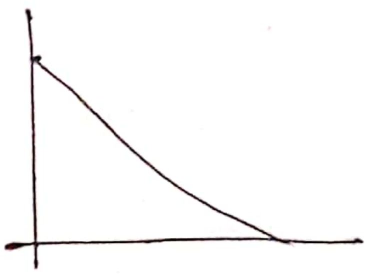
Where, $\mu = \dfrac{b}{a}$

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

(4) Exponential Noise:

The PDF of exponential Noise can be given as:

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



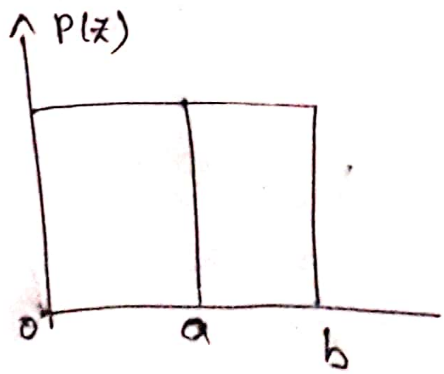
Where, $\mu = \dfrac{1}{a}$

$\sigma^2 = \dfrac{1}{a^2}$

(5) uniform noise:-

The PDF of uniform noise can be given as

$$p(z) = \begin{cases} \dfrac{1}{b-a}, & a \leq f(x,y) \leq b \\ 0, & \text{otherwise} \end{cases}$$



$\mu = \dfrac{a+b}{2}$

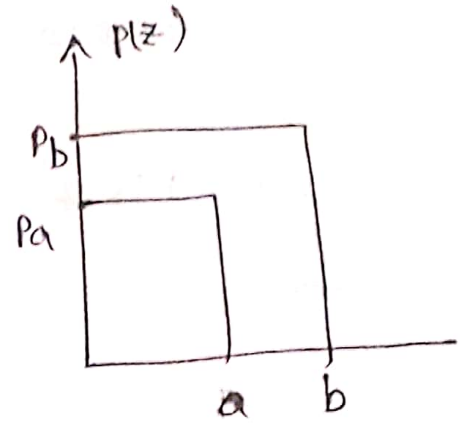
$\sigma^2 = \dfrac{(b-a)^2}{12}$

Scanned with CamScanner

(6) Impulse noise (or) salt & pepper noise:

The PDF of Impulse noise can be given as:

$$p(z) = \begin{cases} P_a, & z=a \\ P_b, & z=b \\ 0, & \text{otherwise} \end{cases}$$



where,

a and b are the grey levels

z represents, number of pixels in the image with different grey levels.

⇒ Presence of noise in image Restoration:-

↳ Image Restoration uses different filters both in spatial domain & frequency domain in the presence of noise

↳ The spatial domain filters used for img restoration in the presence of noise are:

(1) Mean filters.

↳ (i) Arithmetic mean filters

(ii) Geometric " "

(iii) Harmonic " "

(2) Median filters

The freq domain filters used for img restoration in the presence of noise are as follows

(1) Band Reject filter.

(i) Ideal BRF

(ii) Butterworth BRF

(iii) Gaussian BRF

(2) Notch filters.

UNIT-4

IMAGE SEGMENTATION → Area oriented.

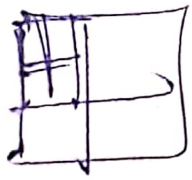
↳ Dividing the img into segments depending upon pixel properties

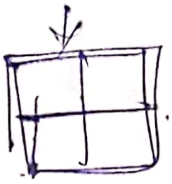
↳ segments which are having similar properties will be and combined & viceversa.

↳ Remaining properties different from img

Local segmentation → segmentation is done in subimages into segments

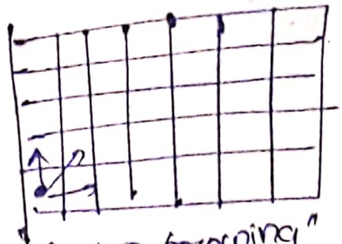
Global " → Dividing whole img will be divided into segments





3 Approaches

(1) Region- forming Regions with similar properties, by selecting a seed
↳ (a new pixel).



Region Growing"

Region splitting
Region splitting & merging.
Region Merging.

Image segmentation:- Image segmentation is the process of dividing the image into partitions depending on the similar properties.

↳ Image segmentation is area oriented but not pixel oriented.

↳ Image segmentation can be broadly classified into 2 types:

(1) Local Segmentation

(2) Global Segmentation.

* Local Segmentation is dividing the subimages which are small windows in a image into segments

* Global segmentation is dividing the whole image into segments.

* Image segmentation can be carried out in the following 3 approaches.

(1) Region approach.

(2) Boundary "

(3) Edge "

* Region in an image or a group of connected pixels with similar properties.

* In boundary approach, the attempt is to locate the boundaries directly that exists in the regions.

* In edge approach the edges are identified first, then they are linked together to form the required boundaries.

***

Region approach for image segmentation:-

Region approach for image segmentation can be done throw the following processes: (1) Region growing

(2) Region splitting

(3) Region splitting & ~~mergin~~ merging

(4) Region merging.

Scanned with CamScanner

(1) Region growing:-

* It is an approach to image segmentation in which the neighbouring pixels are examined and added to the region if no edges are detected.

* Region growing requires a seed to begin with. Ideally the seed would be the Region, but it could be a single pixel.

* A new segment can be formed by finding the similarites in the neighbouring pixel. The pixels which are not similar cannot be combined in the region. This process continues until all the pixels are allocated to a segment.

(2) Region Splitting:-

* It is a top down approach.
* It begins with a whole image and divides into segmented parts which are homogeneous.

* As splitting alone is insufficient, merging ~~an~~ after splitting is desirable, which is known as splitting and merging algorithm.

(3) Region splitting and merging:-

* It is a image segmentation technique that takes spatial information into consideration.

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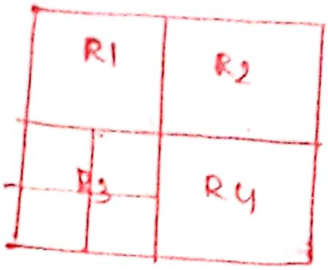
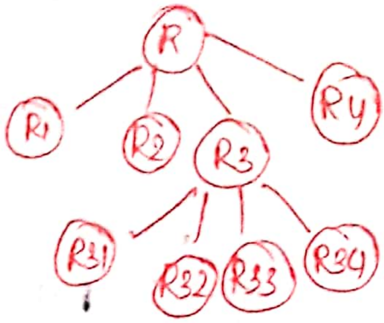
* Region splitting can be carried out in the following steps.

(1) let 'R' Represents the entire image.

(2) Split the image successively into smaller & smaller Quadrant Regions.





* Region merging is the process of combining adjacent Regions that are similar.

* The procedure for splitting and merging algorithm is as follows:

(1) Start with the whole image.

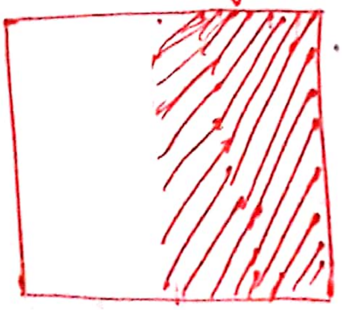
(2) break into different Quadrants

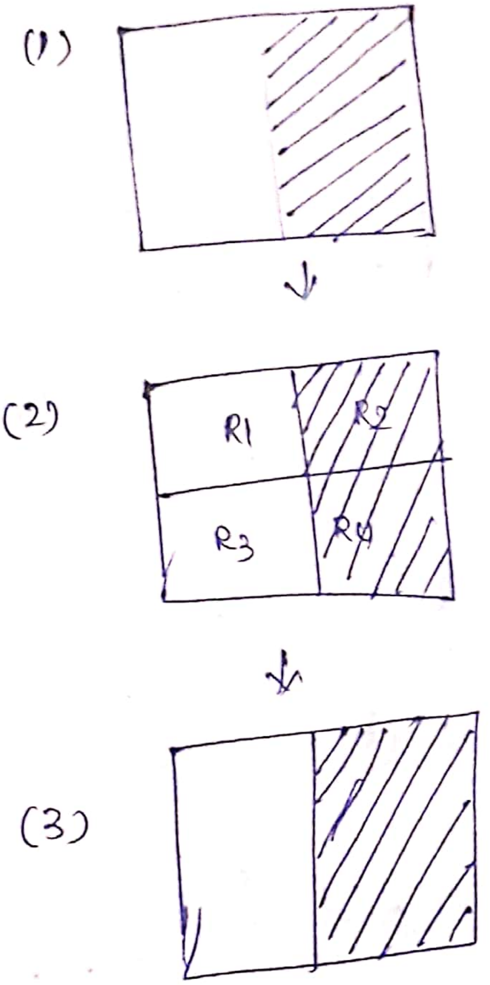
(3) Merge adjacent Regions that are similar.

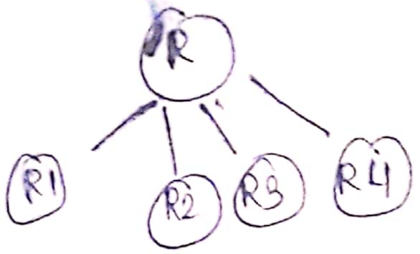
(4) Repeat steps ② and ③ untill no merging and splitting happens.

Problem:

① Apply split & merge algorithm for the following image

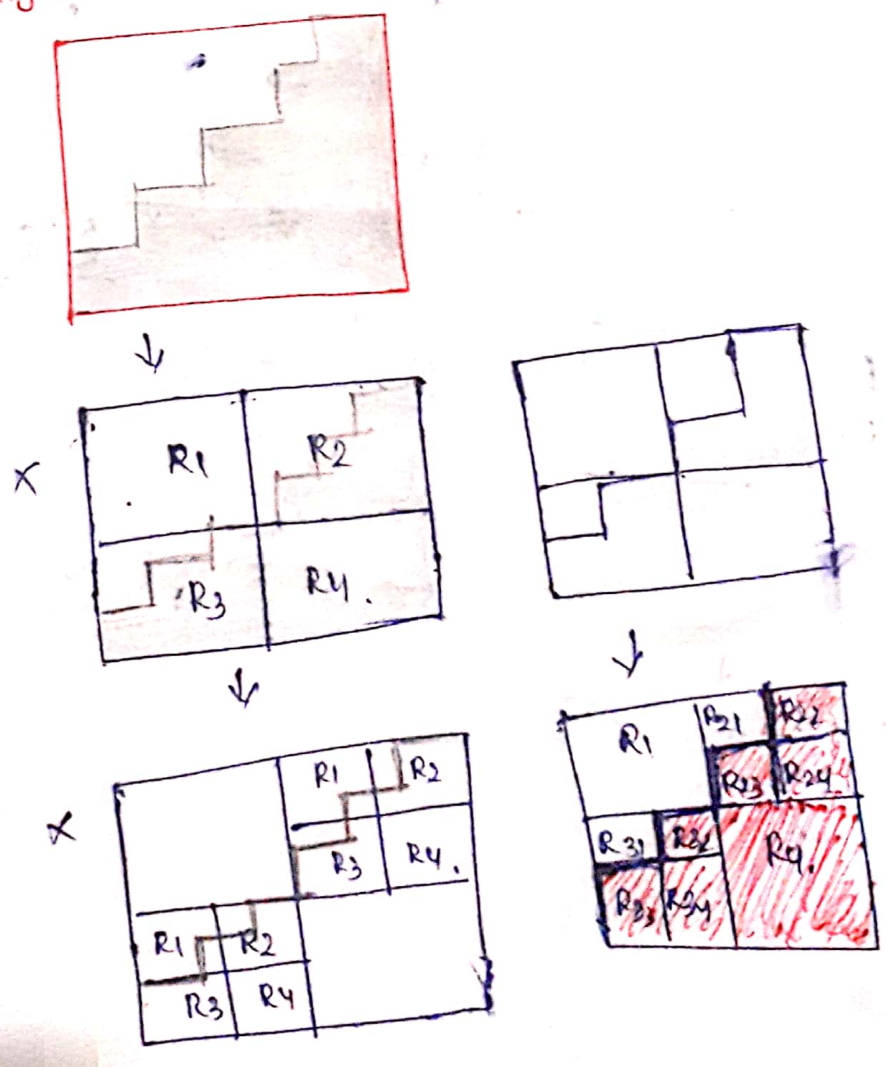


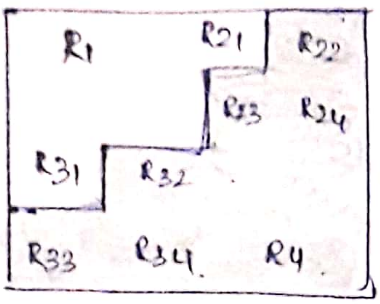


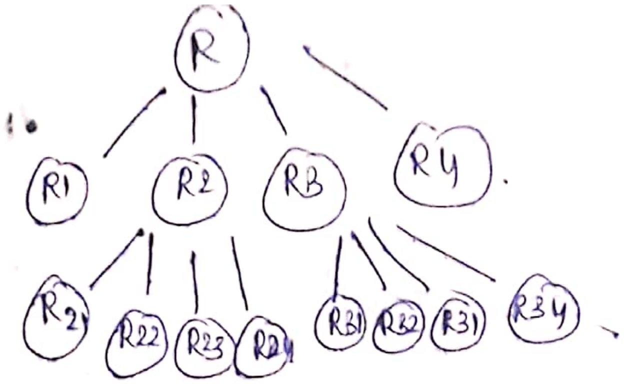


Quatree Representation.

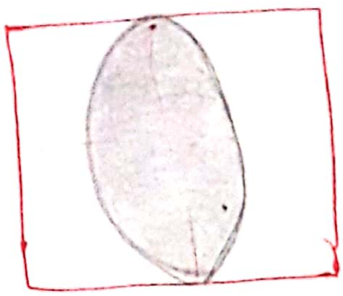
② Apply Split & merge algorithm for the following image

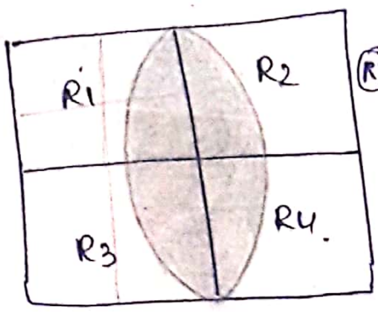


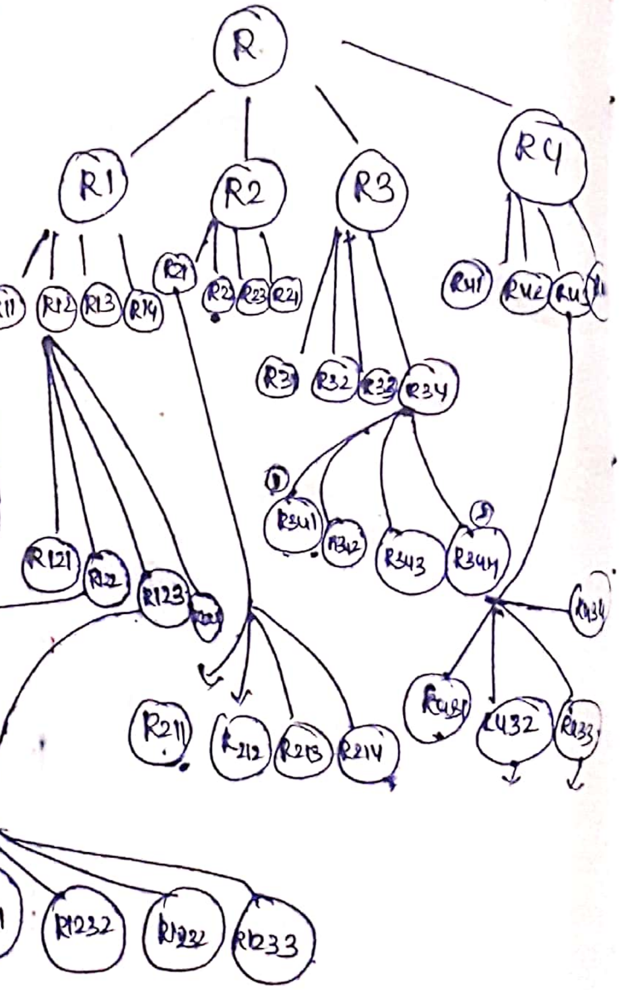


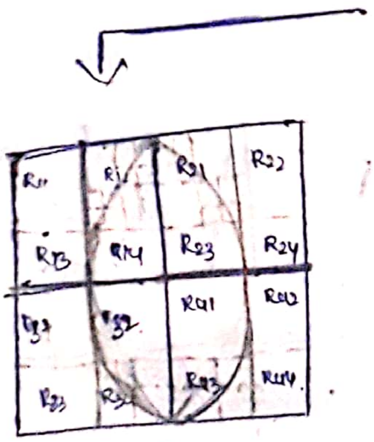


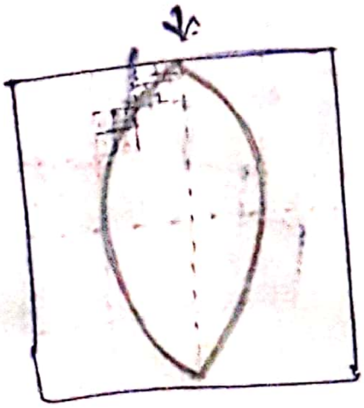
③ Apply split & Merge algorithm for the following img.











⇒ DETECTION OF DISCONTINUTIES :-

* The discontinuties can be detected by knowing the intensity discontinuties in the image.

* Intensity variations can be obtained by passing the mask (3×3) through the image. The response that has been obtained by passing mask through the img is given by,

$$R = \sum_{i=1}^{N} w_i I_i$$

$$R = w_1 I_1 + w_2 I_2 + \cdots + w_9 I_9.$$

* There are 3 types of intensity detections of discontinuties namely (i) point detection
(ii) Line "
(iii) Edge "

(i) point detection :-

* The detection of isolated points embedded in the areas of constant or nearly constant intensity values in an image is given by this principle straight forwardly.

* using the mask the isolated point can be detected at the location on which the mask is centered.

-1	-1	-1
-1	8	-1
-1	-1	-1

(ii) Line detection:-

* The next level of complexity is detecting the intensity discontinuities in line.

* If the first mask was moved around the image it would respond strongly to the lines which are oriented horizontally.

* If the 2nd mask is moved through the image it will detect the line vertically.

* Similarly, the third and fourth masks can detect the lines diagonally i.e $+45^\circ$ and -45°.

-1	-1	-1
2	2	2
-1	-1	-1

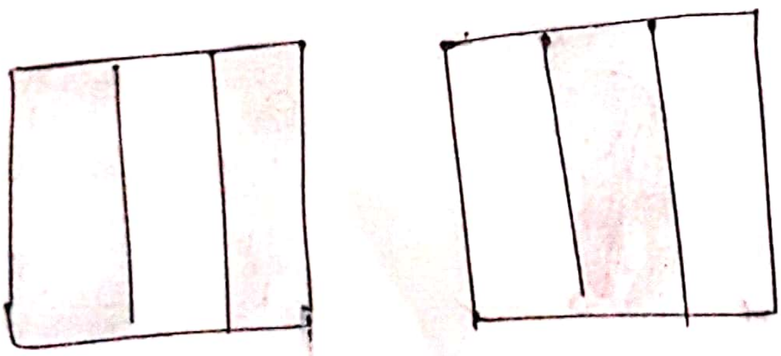
-1	2	-1
-1	2	-1
-1	2	-1

-1	-1	2
-1	2	-1
2	-1	-1

2	-1	-1
-1	2	-1
-1	-1	2

(iii) Edge detection:-

* This is the most common approach for detecting the discontinuity in intensity values.
* The edge detection in img processing is referred to as the gradient.



Edge linking & boundary Detection:-

If the gaps b/w the edges has occurred, due to noise or non-illumination, the edge linking algorithms are used to obtain the link b/w 2 edges & to detect the boundary.

- Edge linking can be carried out in both local & global processing.
- In local processing a small 3x3 neighbourhood is considered. if the edges are having the similar properties then the edges are linked & detected as boundary.
- In global processing the whole img is to be processed and the ~~as a~~ diff edge linking algorithms used for global processing.

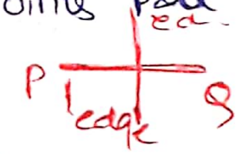
(i) Heuristic search algorithm.

(ii) curve fitting algorithm.

(iii) Hough transform.

(i) Heuristic search algorithm:- This algorithm is used if the edges ~~or~~ gaps are not too long.

- Heuristic search algorithm used to link ~~to~~ 2 edge points P&Q ea. is as follows.



(1) Identify the 3 neighbours for pt 'p'.

(2) compute the edge quality function for all the pts from step 1.

(3) Select the one that maximizes the edge quality function from p to those points

(4) use the pt from step 2 as the starting pt for the next iteration.

(5) Repeat the process untill pt 'Q' is Reached.

(6) The St line obtained from p to Q is detected as boundary.

(ii) curve fitting

↳ This algorithm is used if the edge pts are thinly distributed.

↳ The algorithm is as follows:-

(1) Begin by establishing a st line b/w 2 edge pts i.e from p to Q.

(2) Compute the ler distance from the st line to other edge points.

(3) Choose the won whose ler dis is less as the next pt for iteration.

(4) Repeat the process untill all the edges are linked

(iii)

Consider P & Q with coordinates x_1, y_1 and x_2, y_2; the edges can be linked by using

$$\frac{y-y_1}{y_1-y_2} = \frac{x-x_1}{x_1-x_2}$$

In polar co-ordinates the st line $y = mx + c$ can be represented as $\rho = x\cos\theta + y\sin\theta$. Where ρ and θ are defined as vectors. obtained from origin to the nearest pt from the st line.

Thresholding:-

* The gradient for 2D function $f(x,y)$ is given by

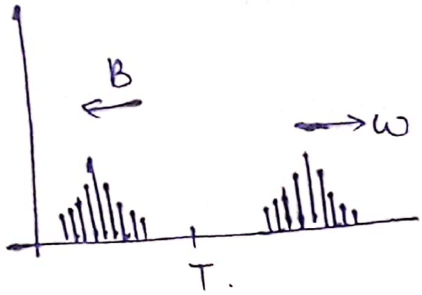
$$\nabla f = \left| \frac{\partial f / \partial x}{\partial f / \partial y} \right|$$

⇒ EDGE LINKING:-

Thresholding:-

* It is the method of labelling the pixels which belongs to one or more threshold levels.

* Thresholding is represented in the form of histograms.



* There are 2 types of thresholding

(1) Global thresholding

(2) Adaptive "

(1) Global thresholding:

* It is used when only 1 threshold level is present.

* Segmentation is acheived by ~~(passing the structuring element on each & every pixel.)~~ scanning each & every pixel and labelling it as either background or foreground.

* Heuristic approach is used for global thresholding in order to obtain the threshold level T automatically.

* The Heuristic approach is as follows:

(1) select an estimate for 'T'

(2) segment the image with threshold level 'T.' This produces 2 grps of pixels G_1 consisting the pixels with grey levels $> T$ and G_2 consisting " "

with grey levels < T.

(3) compute the avg grey level values μ_1 and μ_2 for the regions G1 and G2 respectively.

(4) Obtain the new threshold level $T = \frac{1}{2}(\mu_1+\mu_2)$

(5) Repeat the process from step2 to step4 until the required is achieved.

(2) Adaptive thresholding:-

* This method is used if there are 2 or more threshold levels.

* As the threshold levels are more we cannot acquire the required img exactly. There by the img is divided into constituent regions and global thresholding is applied for each region individually.

Morphological image processing:-

Morphology is process which is used to extract the edges of the img filter the img & to skeletonize the img.

The process of converting grey scale img into black & white img is known as binarisation.

* Morphology is the collection of non-linear processes which can be applied to the images to remove the details which are smallest than the reference shape is known as structuring element.

* Morphological img processing is the process of moving the structuring element over the binary img which is to be modified in such a way that it is centered over each & every pixel of the img

* Morphology can be processed in the following 2 ways
  (1) ~~Dia~~ Dilation
  (2) Erosion

(1) Dilation:

* It is the process of enlarging the img & obtaining the edges for the images.
* When the structuring element is moved on to the img, the center pixel becomes 1, if any one pixel overlapps with the structuring element otherwise zero.

* If 'A' is the i/p image and 'B' is structuring element dilation can be acheived by $A \oplus B$

(2) Erosion:-

* It is the process of shrinking the img.
* ~~Wheren~~ when the structuring is moved on to the img, the center pixel becomes 1, if every pixel

overlaps with the structuring element perfectly. otherwise zero.

* Erosion is indicated as $A \ominus B$ (i/p img $\to$ A, structuring element $\to$ B).

Opening & closing:-

* The combination of dilation & erosion is defined by opening and closing

* opening is performed where first erosion followed by dilation.

$$\text{Opening} = (A \ominus B) \oplus B$$

* Closing is the process where the ~~dilation~~ dilation is performed first then erosion.

$$\text{closing} = (A \oplus B) \ominus B$$

* ⇒ Hit or Miss Transformation:-

- This is very imp transformation which is used for morphological img processing.
- This contains 2 structuring elements B_1 & B_2
- Hit or Miss Transformation is given by

$$A \odot B = (A \ominus B_1) \cap (A^c \oplus B_2)$$

Set Theory

* Morphological img processing can be performed by the following set of theories

* If V is the set of pixels for an image, morphology uses

(1) Union

(2) Intersection.

(3) Complement

(4) Reflection.

(5) Translation.

Ex:-

4	0	1	0	1	0
3	0	0	1	0	0
2	0	0	0	0	1
1	0	0	1	0	0
0	0	1	0	1	0
	0	1	2	3	4

$V = \{(1,0), (3,0), (2,1), (0,2), (4,2), (2,3), (1,4), (3,4)\}$

Reflection :-

$V = \{(-1,0), (-3,0), (-2,-1), (0,-2), (-4,-2), (-2,-3),$

$(-1,-4), (-3,-4)\}$.

Translation:

$V = \{(2,1), (4,1), (3,2), (1,3), (5,3), (3,4), (2,5), (4,5)\}$

UNIT-V

IMAGE COMPRESSION

* B.W must be less
* Storage must be less

↳ Image compression is defined as the mapping from higher dimensional space to lower dimensional space.

↳ The process of reducing the number of bits required to represent an image with an acceptable image quality is known as image compression.

Need for image compression:-

- In multimedia applications the amount of information that is handled by computers has grown exponentially, hence the storage & transmission of digital images is a major problem.
- Generally, high amount of data is required to represent an image clearly thereby the storage space, bandwidth, and transmission time is being increased which is unable to handle.
- One of the possible solutions for this problem is to compress the images there by the storage space and transmission b.w can be reduced.

- Reducing the B.W will result in significant reduction of cost also.

- In a compact way image compression offers many ways to represent the images so that the images can be stored in a compact way & can be transmitted faster.

Redundancies in Images :-

↳ Image compression can be acheived by using 2 processes
  (1) Redundancies
  (2) Irrelavancy Reduction.

↳ Redundancy means dublication.

↳ Irrelavancy Reduction means the parts of image information that will not be noticed by human visual system. (pixel wise reducing the pixels)

Classification of Redundancy in Images :-

- Redundancy
  - statistical
    - Interpixel
      - Spatial
      - Temporal.
    - coding
  - psychovisual
    (Image wise Reduction)
    (unvisible for naked eye will be Removed)

Scanned with CamScanner

↳ Interpixel Redundancy is due to the correlation b/w neighbouring pixels of an image.

↳ coding redundancy is considered with representation of information in the form of codes.

Example: Huffman, Shanon fano, Arithmetic coding.

↳ Spatial redundancy represents the correlation b/w neighbouring pixels of an image.

↳ Temporal redundancy is the correlation b/w the pixels in the successive frames of a video. This is efficiently used in video compression. (check 1 frame to other frame) mainly used in video procession.

↳ psychovisual redundancy is associated with human visual system. Eliminating the psychovisual redundancies will lead to efficient compression.

Fedelity criterian:-

↳ The amount of exactness with which the image is copied or reproduced is known as 'fedelity'

↳ To determine exactly what information is important and able to measure the image quality, we need to define the fedelity criterian.

↳ This is of two types: (1) objective fedelity
(2) Subjective "

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↳ In objective fedelity criterian the measure of the information loss can be expressed as the original image and the compressed image. If $f(x,y)$ is the i/p image and $\hat{f}(x,y)$ is the decompressed image then error $e(x,y)$ is given by

$$\boxed{e(x,y) = \hat{f}(x,y) - f(x,y)}$$

The total error can be represented as

$$\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left[\hat{f}(x,y) - f(x,y) \right]$$

Root mean square error for an image

$$\boxed{e_{rms} = \sqrt{\frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left(\hat{f}(x,y) - f(x,y) \right)^2}}$$

signal to noise ratio for the img output

$$\frac{S}{N} = \frac{\text{output}}{\text{error}}.$$

$$\boxed{\frac{S}{N} = \frac{\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left[\hat{f}(x,y) \right]^2}{\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left[\hat{f}(x,y) - f(x,y) \right]^2}}$$

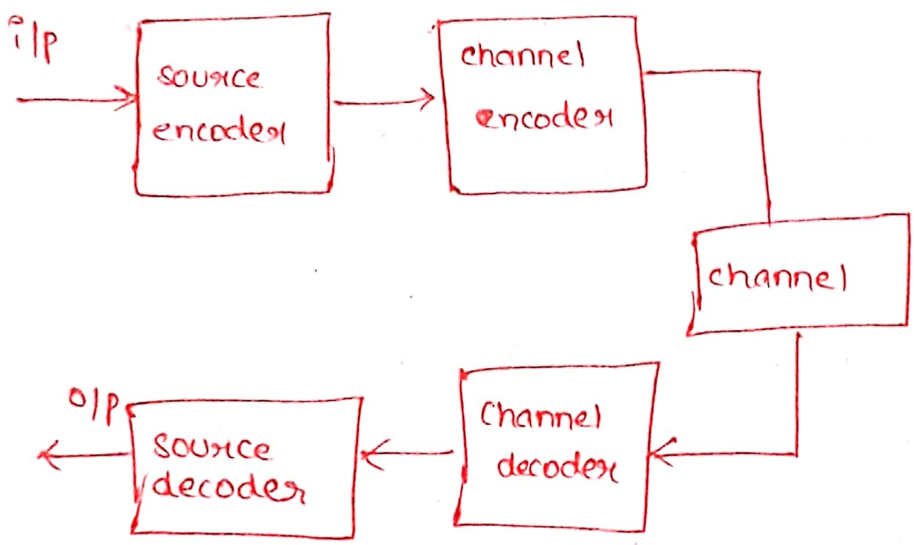
↳ in subjective fedelity criteria the measure of image quality is being done by the subjective evaluations of human observer. The evaluations of Rating scale are said to be based on subjective fedelity criterian.

↳ The Rate of Scales for image quality are excellent, very good, good, Average, poor.

Image compression schemes:-

Image compression schemes consists of source codec module (encoder and decoder) and channel codec module

The block diagram of img compression scheme is as follows:



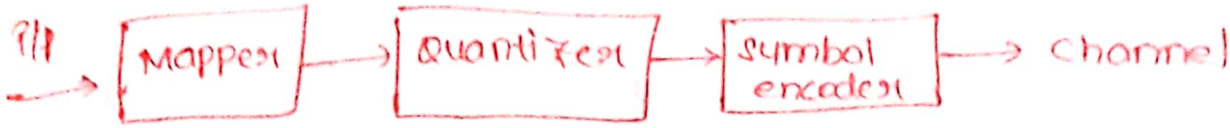
Source encoding & decoding:-

↳ source encoding is used to Represent the data in the sequence of bits.

↳ It is efficiently used to reduce the redundancies & also Entrophy (Avg number of bits required to represent the img)

↳ source encoder consists of mapper, quantizer & symbol encoder.

Q11



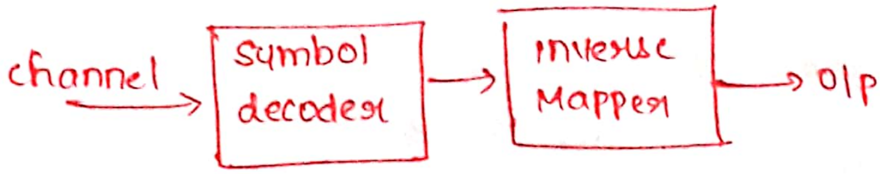
↳ Mapper is used to map the given data into a format which is designed to reduce interpixel redundancies.

↳ This is reversable process the examples ~~for~~ of mapping are Runlength coding & transform coding.

↳ Quantizer is used to reduce the psyovisual redundancies, as this is irrevarsable process we cannot use this in source decoder.

↳ Symbol encoder is used to produce a fixed length code for quantizer output.

↳ Source decoding is used to produce the original data back by using symbol decoder and inverse mapper.



↳ Channel is used as medium over with the comm takesplace.

↳ channel encoding & decoding are used to protect the communication system against noise & other transmission errors in the channel.

EX:- Hamming codes.

Classification of image compression schemes:-

Image compression schemes are briodly classified into 2 types.

(1) Lossles image compression scheme
(2) Lossy " " "

↳ In Lossless there will be no loss of information i.e the reconstructed image will be the exact replica of original image.

↳ This is mainly used in medical image applications.

↳ compression Ratio in lossless is very less.

↳ compression Ratio is defined as the Ratio b/w uncompressed size & compressed size.

↳ In lossy there will be some loss of information. i.e Reconstructed image will be different when compared to original img.

↳ This is mainly used in multimedia applications.

↳ compression Ratio is high. lossy img compression is also known as visually lossless. As it doesn't have visible degradation.

Fundamentals of information theory:-

↳ Information theory explains the lossless and lossy in mathematical basis i.e interms of entrophy, mutual information and rate distortion concepts.

Entropy:-

↳ Entropy is defined as the avg number of bits used to Represent the image.

↳ Entropy is given by,

$$\boxed{H = \sum_{i=1}^{N-1} p(x_i) \log\left(\frac{1}{p(x_i)}\right)}$$

Mutual information:-

$$\boxed{\begin{aligned} I(X;Y) &= H(X) - H(X/Y) \\ I(X;Y) &= H(Y) - H(Y/X) \end{aligned}}$$

Shanon fano coding:-

↳ It is a top down approach and the algorithm for shanon fano coding is as follows:

(1) Arrange the given source symbols in decreasing order.

(2) The symbols are divided into 2 groups with equal probabilities or nearly equal probabilities.

(3) The code word '0' is given for the upper half of probabilites & the lower half as '1'.

(4) Repeat the process untill each source symbol have individual code word.

① construct the shanon fano code for "MUMMY".

(1) Determine the probability of occurance for the given word

$$\text{Probability of a symbol} = \frac{\text{Number of occurance of symbol in a message}}{\text{Total number of symbols in a message}}.$$

$P(M) = \frac{3}{5}$.

$P(U) = 1/5$

$P(Y) = 1/5$.

(2)

Symbol	probability			Codecoord	length
M	3/5	0		0	1
U	1/5	1	0	10	2
Y	1/5.	1	1	11	2.

(3) $$H = \sum_{i=1}^{N-1} P(x_i) \log \frac{1}{P(x_i)}$$

$$H = \frac{3}{5} \log_2 \frac{1}{(3/5)} + \frac{1}{5} \log_2 \frac{1}{(1/5)} + \frac{1}{5} \log_2 \frac{1}{(1/5)}$$

$H = 1.37$.

(4) Avg length $(\bar{N})$:- $P_K \times l_K$.

$$\boxed{\sum_{K=0}^{N-1} P_K \times l_K.}$$

Avg length $= 3/5 \times 1 + 1/5 \times 2 + 1/5 \times 2$.

Avg length $(\bar{N}) = 1.4$

(5) Efficiency $= \dfrac{H}{\text{Avg length}}$.

$$= \frac{1.37}{1.4} = 0.97$$

$$\eta = 97\%.$$

Huffman coding:-

① Obtain the Huffman code for the word "COMMITTEE"

$p(C) = 1/9$

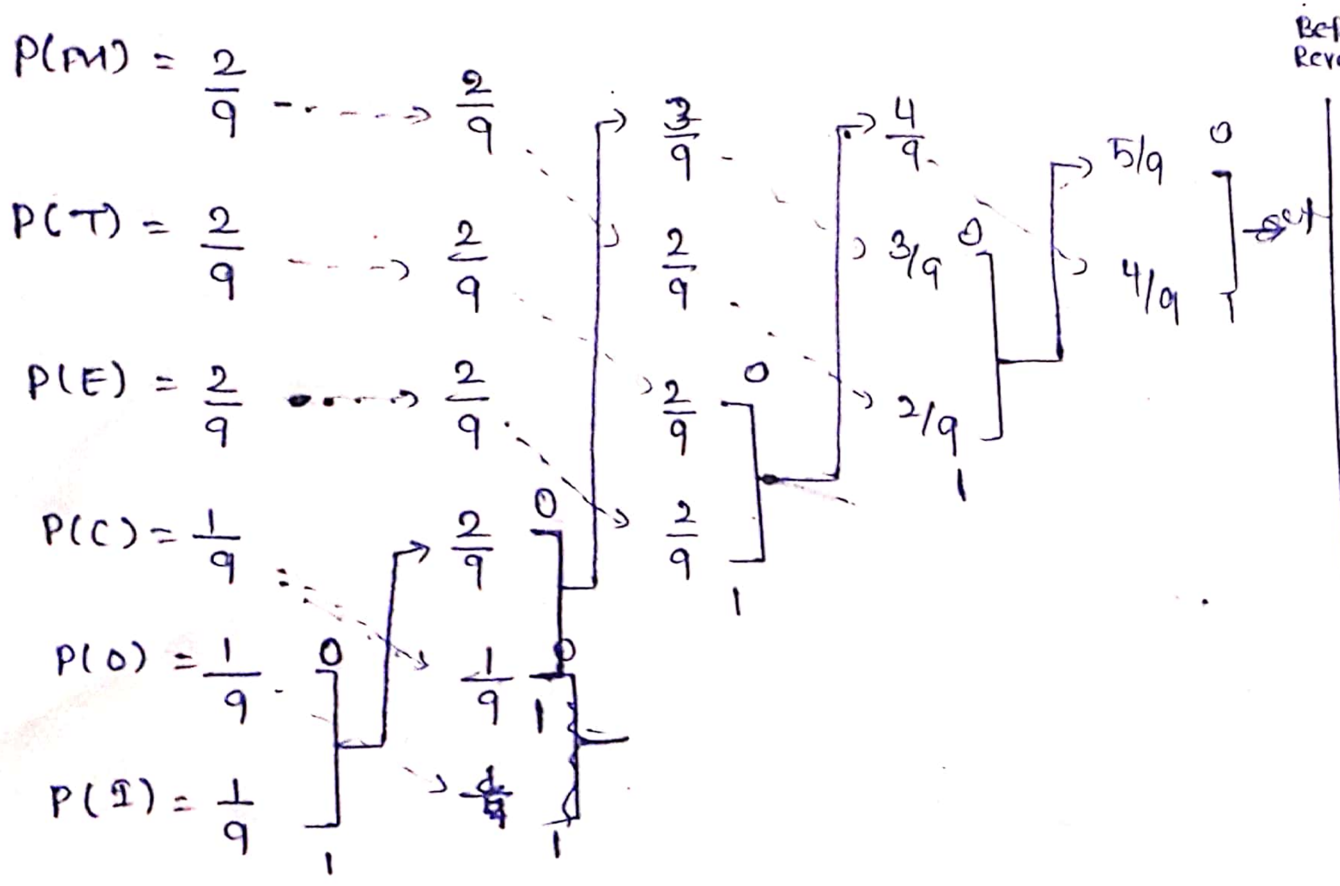
$p(O) = 1/9$

$p(M) = 2/9$

$p(I) = 1/9$

$p(T) = 2/9$

$p(E) = 2/9$



Codewords Before Reversing		Length
10	01	2
01	10	2
11	11	2
100	011	3
0000	0000	4
1000	0001	4

$$\text{entropy}, H = \sum_{i=1}^{N-1} P(x_i) \log \frac{1}{P(x_i)}$$

$$= \left(\frac{2}{9} \times \log_2 \frac{1}{2/9}\right) * 3 + 3 \times \left(1/9 * \log_2 \frac{1}{1/9}\right)$$

$$H = 2.503$$

$$\text{Avglength } N = \sum_{K=0}^{N-1} P_K \times l_K$$

$$N = \left[\left(\frac{2}{9} \times 2\right) * 3\right)\right] + \frac{1}{9} \times 3 + \frac{1}{9} \times 4 + \frac{1}{9} \times 4$$

$$N = 2.55$$

$$\text{efficiency}, \eta = \frac{H}{N}$$

$$= \frac{2.503}{2.55}$$

$$= 97.9\%$$

Non binary huffman coding:-

This is also known as Ternary huffman coding.

① calculate the efficiency for the word "COMMITTEE" using Ternary huffman coding.

$P(C) = 1/9$ $\quad P(T) = 2/9$

$P(O) = 1/9$

$P(E) = 2/9$

$P(M) = 2/9$

$P(I) = 1/9$

$P(M) = \frac{2}{9}$

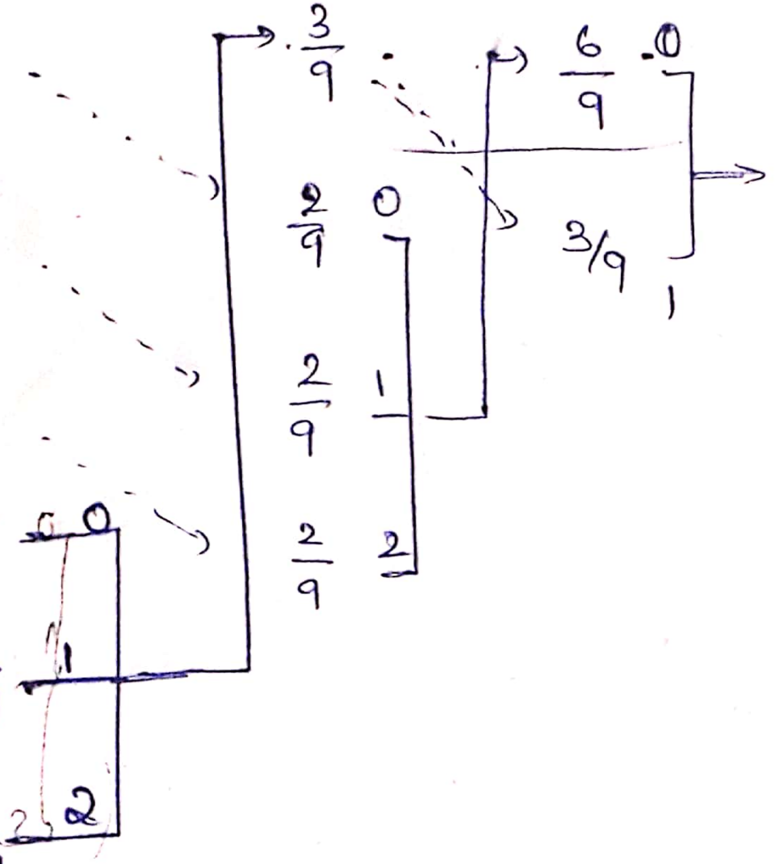
$P(?) = \frac{2}{9}$

$P(E) = \frac{2}{9}$

$P(C) = \frac{1}{9}$

$P(O) = \frac{1}{9}$

$P(?) = \frac{1}{9}$



Codeword		Length
0 0	0 0	2
1 0	0 1	2
2 0	0 2	2
0 1	1 0	2
1 1	1 1	2
2 1	1 2	2

1) $H = \sum_{i=1}^{N-1} p(x_i) \times \frac{1}{\log(1/p(x_i))}$

$= 3\left[2/9 \times \frac{1}{\log(1/2/9)}\right] + 3\left[1/9 \times \frac{1}{\log(1/1/9)}\right]$

$H = 2.503$

2) $N = \sum_{K=0}^{N-1} P_K \times l_K$

$N = (2/9 \times 2)3 + (1/9 \times 2)3$

$N =$

3) $\eta = \frac{H}{N} = \frac{2.503}{2} = \underline{\underline{1.25}}$

Runlength coding (RLC)

↳ Runlength coding is used whenever there are so many Repetitions of source symbols occur.

↳ This coding is mainly used to reduce the spacial redundancies by coding ~~member~~ no of symbols in a run.

↳ Run length coding maps a sequence of number of symbols into the sequence of symbol pairs.

$\boxed{(\text{Run}, \text{value})}$ → values (1 or 0)

↳ No of times the symbols are repeated

↳ The term Run indicates the Repetion of symbol

↳ RLC is classified into 2 types:

Scanned with CamScanner

(1) One dimensional RLC

(2) Two dimensional RLC

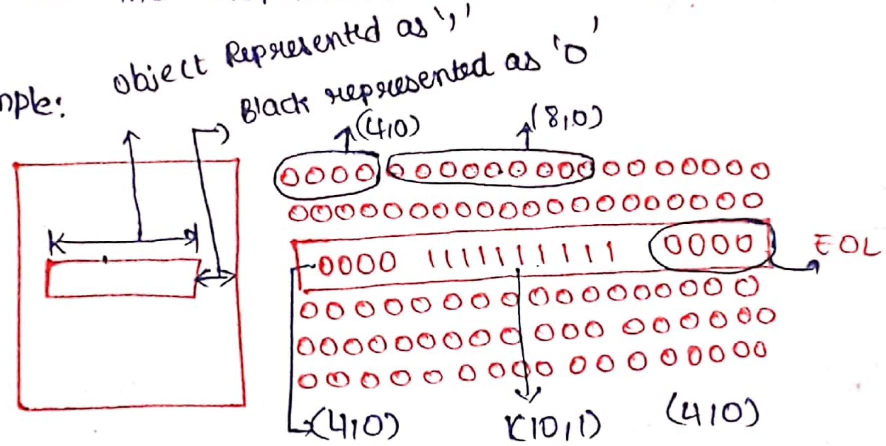
(1) One dimensional RLC:-

↳ In 1-D RLC each line is scanned independently.

↳ Each line will have EOL (End of Line) command at the end of each line.

↳ The decoder knows the EOL ~~for~~ scan line, which is used for the representation of image.

Example:

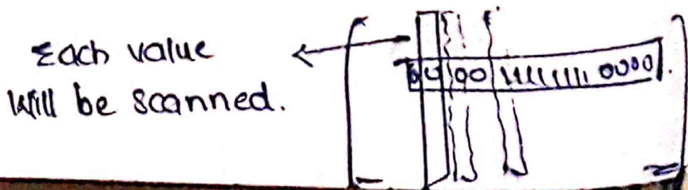


↳ Each row is scanned successively and the corresponding Runlength code is transmitted.

↳ In the given Example, The third is scanned, The Runlength code (4,0) (10,1) (4,0) is transmitted.

(2) Two dimensional RLC:-

↳ 1D RLC utilises the correlation b/w the pixel within a scan line where as 2D RLC utilises the correlation, comparis (horizontally & Vertically) b/w the neighbouring scan lines.



↳ 2-D RLC achieves highest coding efficiency when compared to 1-D RLC.

↳ Practical application purpose we are using 2-D RLC

Arithmetic coding:-

↳ Arithmetic coding doesnot generate individual code words for each character in the word, It performs the coding operations on the entire block of data based upon the next character.

↳ In arithmetic coding the interval from ~~zero~~ 0 to 1 is divided according to the probabilites of the occurances.

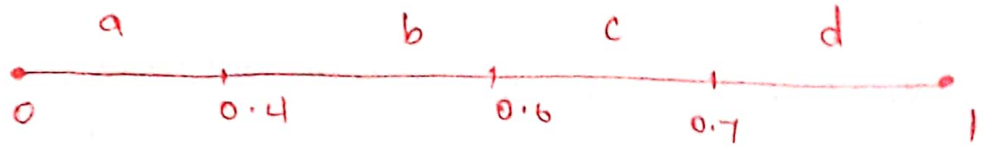
↳ Arithmetic coding is more efficient when compared to huffman coding.

① A source emits the source symbols {a, b, c, d} with the probabilities 0.4, 0.2, 0.1 and 0.3 respectively. construct arithmetic coding to encode and decode the word "dad"

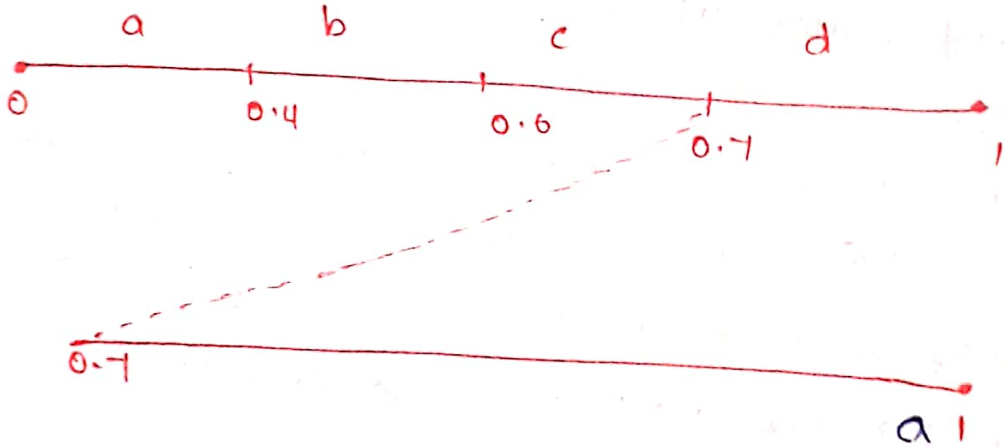
The symbol probabilities and their corresponding ranges are tabulated below:

Symbols	a	b	c	d
probabilities	0.4	0.2	0.1	0.3
sub ranges	(0-0.4)	(0.4-0.6)	(0.6-0.7)	(0.7-1)

Initially the Range is 0 to 1 in which the sub ranges of probabilities are marked.



Step-2:- The first character to be transmitted is 'd' whose subrange is (0.7 to 1)



Step3: Find the subrange for each symbol in b/w the intervals (0.7 to 1) where low and high range values for each symbol can be calculated from the formulas.

low = low + range(low - range)

high = high + range(high - range)

Low range & high range depends upon the individual symbols.

To compute the interval for symbol 'a' in the interval 0.7 to 1

low = 0.7

range - low

range = 1 - 0.7 = 0.3

for symbol 'a' low.range = (0 - 0.4)

low range ↓   high range ↓

low   range   low range

low: 0.7 + 0.3(0) = 0.7.

high: 0.7 + 0.3(0.4) = 0.82.

low   range.   high range

'b' value

for symbol 'b'

b = (0.4 - 0.6).

low = 0.7 + 0.3(0.4) = 0.82

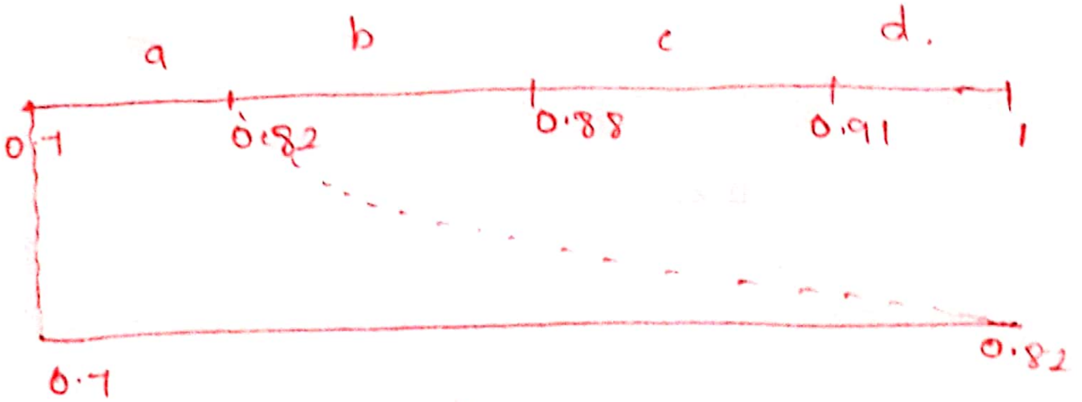
high = 0.7 + 0.3(0.6) = 0.88

For symbol 'c'

c = (0.6 - 0.7)

low = 0.7 + 0.3(0.6) = 0.88

high = 0.7 + 0.3(0.7) = 0.91



low = 0.7

range = 0.12

symbol 'a' :- (0 - 0.4)

low = 0.7+0.12(0) = 0.7

high = 0.7+0.12(0.4) = 0.748

symbol 'b' :- (0.4 - 0.6)

low = 0.7+0.12(0.4) = 0.748

high = 0.7+0.12(0.6) = 0.772

symbol 'c' :- (0.6 - 0.7)

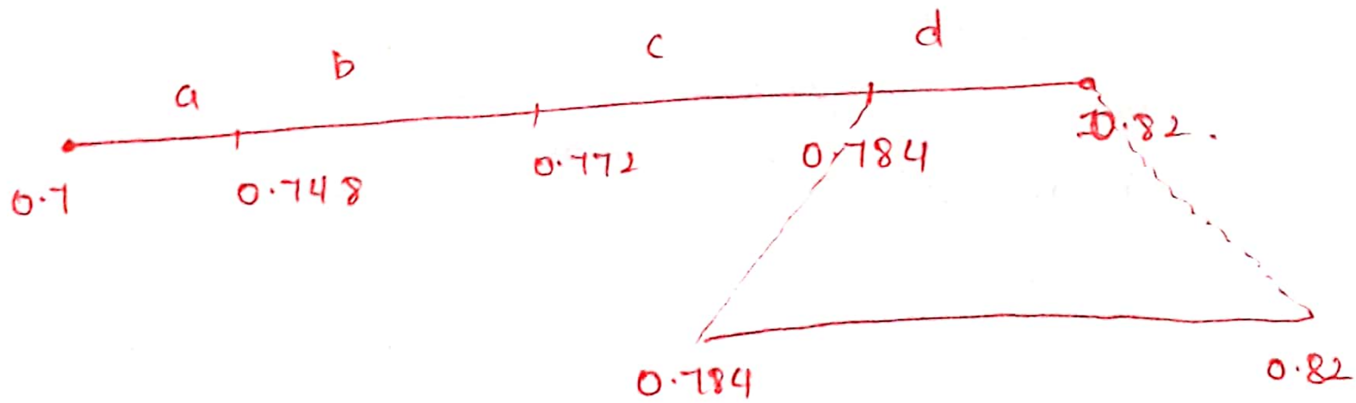
low = 0.7+0.12(0.6) = 0.772

high = 0.7+0.12(0.7) = 0.784

x

(symbol 'd' :- (0.7 - 1)

low = 0.7+0.12(0.7))x



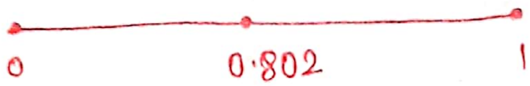
$$\text{tag value} = \frac{0.784+0.82}{2}.$$

tag value. = 0.802.

The tag value & its symbol probabilities will be send to the receiver after receiving the tag value the decoder decodes encoder data.

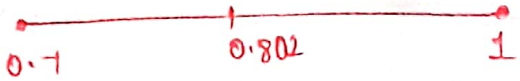
Decoder:-

The tag value received is 0.802 and the initial interval is b/w 0 to 1



* The tag value is compared with the subranges, We find that 0.802 lies b/w (0.7 to 1) hence the corresponding decoded symbol is 'd'.

* As decoded symbol is 'd' the interval 0 to 1 changes to (0.7 to 1)



* The new tag value is obtained from

$$t^* = \frac{tag - low}{range} = \frac{0.802 - 0.7}{(1 - 0.7)} = 0.34 \Rightarrow 'a'.$$

As 0.34 lies in the interval 0 to 0.4 the decoded symbol is 'a'.

Now the new interval is 0 to 0.4

$$t^* = \frac{0.34 - 0}{0.4} = 0.85 \Rightarrow "d"$$

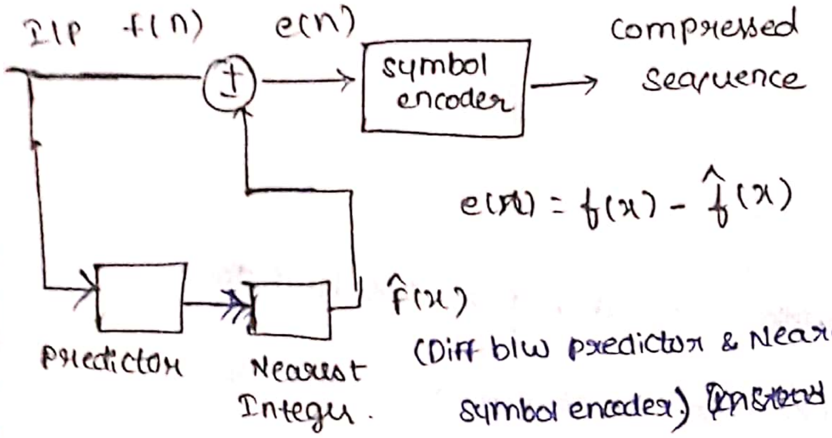
As 0.85 lies in the interval 0.7 to 1 the decoded symbol is "d"

Thus the word DAD is decoded.

Scanned with CamScanner

Predictive coding:-

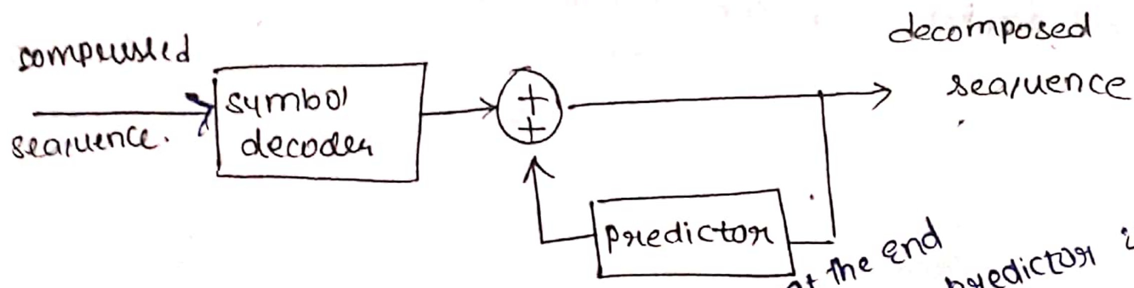
Lossless:-



$$e(x) = f(x) - \hat{f}(x)$$

(Diff b/w predictor & Nearest Int is given as i/p to symbol encoder)

Encoder



at the end encoder predictor is given that is added up to the signal such that o/p = i/p.

Decoder.

(medical applications)

The predictive coding involves the prediction of current pixel value based upon the previously processed pixels. usually the difference b/w the predicted value and the actual value is transmitted.

The receiver makes the same prediction at the receive section such that it adds the predicted value in order to reconstruct the original value.

Adv

↳ Depending on the previous data we can predict whether the o/p is accurate or not

↳ more efficient (compression can be more effectively acheived)

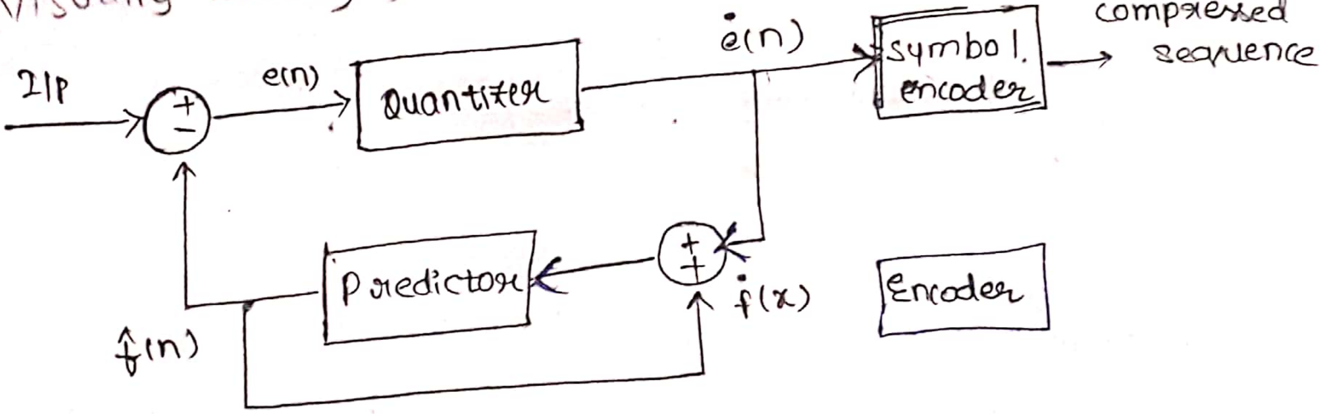
In lossless predictive coding as there is no loss of information instead of quantizer nearest Integer block is added. (because of information lost if we use quantizer block).

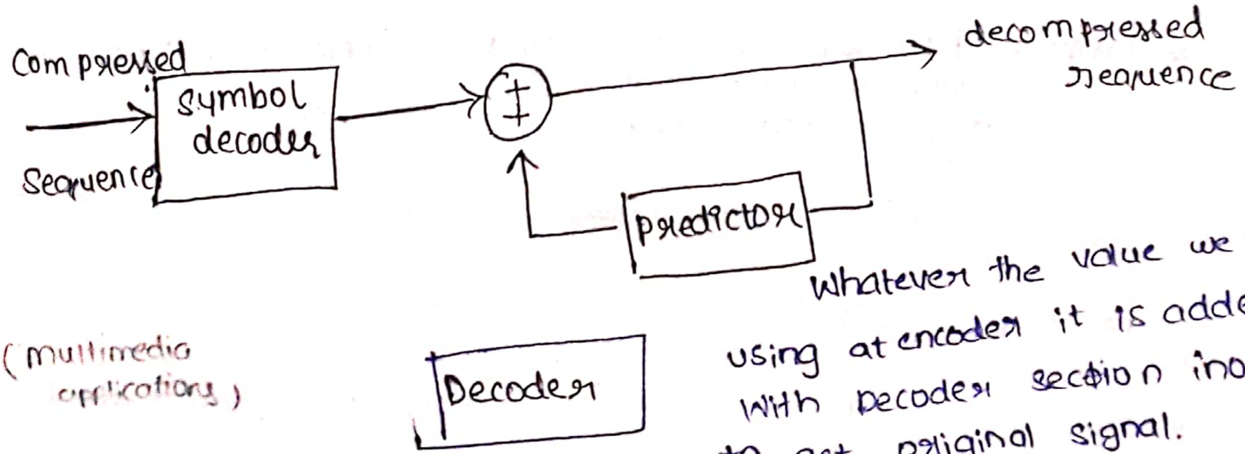
The nearest integer block rounds, off the o/p of the predictor denoted by $\hat{f}(n)$ is used to form the prediction error $e(n)$ which is given by

$e(n) = f(n) - \hat{f}(n)$ (Diff b/w predicted value & actual value)

Lossy predictive coding:-

In Lossy predictive coding the quantizer block replaces the nearest integer block as we used in lossless (visually lossless) → not visible to the human eye





(multimedia applications)

Whatever the value we r using at encoder it is added up with Decoder section inorder to get original signal.

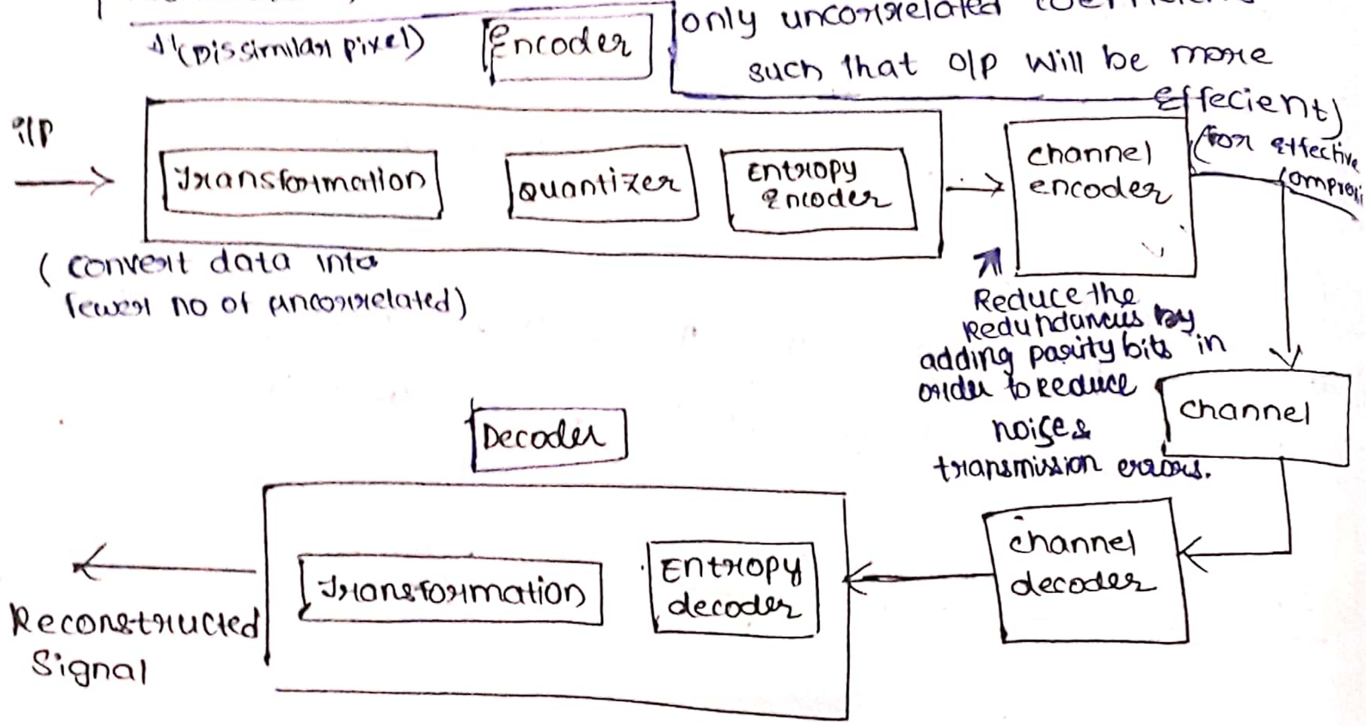
↳ In encoder the quantized values along with predicted values are being transmitted.

**

Reason:- But in Real case Redundancies can be removed by correlated coeff but in Transform based coding done by uncorrelated coeff

Transform based coding: (When we compare correlated to uncorrelated, uncorrelated are very few so we can use only uncorrelated coefficients such that o/p will be more effecient)

(dissimilar pixel)



* Transformation is essential tool for an image compression. The purpose of transform based coding is to decompose the set of correlated coefficients into a set of uncorrelated coefficients such that the energy is more concentrated (mainly concentrated on) on as few coefficients as possible. (convert a data to frequency domain)

* Transformation block is used to obtain the transformed coefficients. For efficient compression the transform should have the following properties.

(1) Decorrelation: The transform should generate uncorrelated transform coefficients (as few as possible)

(2) Linearity: Linearity principle allows 1-to-1 mapping b/w the pixel values and transform coefficients.

(3) orthogonality:-

(4) Quantizing: This is also known as orthogonality and it is the process of eliminating the redundancies in the transformed image.

(5) Entropy Encoder is used to reduce no of bits inorder to Represent the quantizer o/p commonly used techniques are huffman, shannon fano, Arithmetic coding etc.

* The o/p of encoder is basically a bit stream which is sent through channel encoder inorder to avoid the noise & transmission errors.

* Channel is the medium where the communication takes place.

(Quantization is irreversible process so we cannot use in decoder)

* The decoder performs the reverse process of the encoder inorder to get the reconstructed image.

JPEG 2000:-

↳ Quantizer: mainly used for rounding up values. In case of this case to Reduce the no of bits inorder to represent the img.

* 1st JPEG has started in the year 2000.
* JPEG stands for joint photographic experts group.
* It is an international standard used for still photographic image compression.
* It is based on wavelet transforms & supports both lossless and lossy compression of colour images.

Need for JPEG 2000:-

* Initial version is JPEG & Next version is JPEG-200.
* JPEG 2000 mainly uses wavelet transformation (DWT) or DCT (Discrete cosine transform).
Discrete

Advantages | Need:.

① (JPEG 2000). compress
* This will provides Low Bitrate compression (effective showing of img can be acheived).

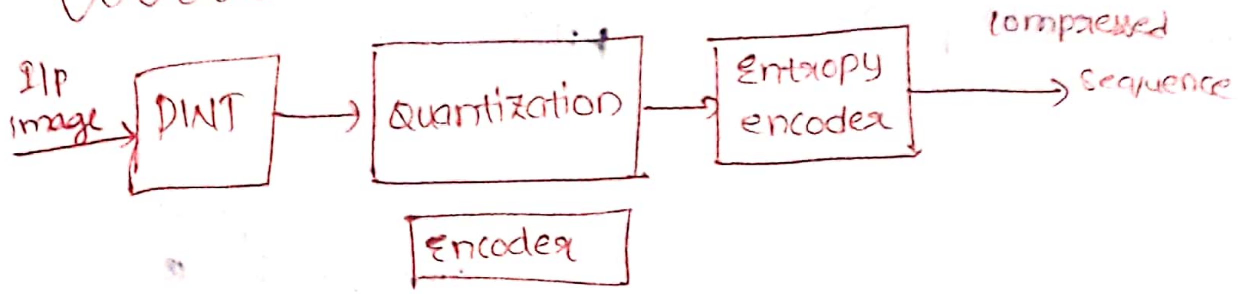
②
* provides both lossles and lossy compression.
compared to diff schemes this provides,

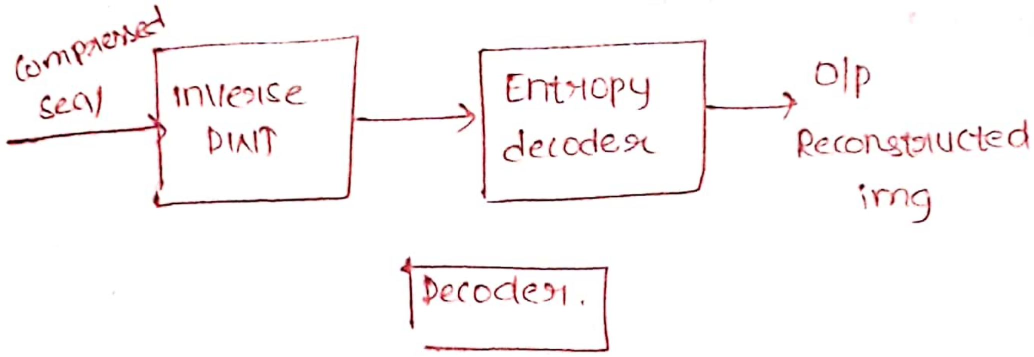
③
* Single Architecture decomposition. → having 44 mode inorder to compress the img.
(getting all 44 Modes in single compression technique or only 1 architecture) decompositon.

④
* Though the environment is noisy JPEG 2000 img can transmit the images (error resistance) is high. due to this provide the transmit the data without errors

⑤
* follow Region (RBC) based coding. (in Image segementation depending upon "Region Growing") other standards does not support (RBC)

Block diagram of JPEG-2000:-





Steps involved in JPEG 2000:-

Step-1:- RGB - YUV

RGB colour img can be converted into YUV image (~~compprinence~~ crominence and brightness of img) (black & white).

Step-2:- Divide entire into 8x8 matrix (8 Rows & 8 colums).

Step-3:- Transform each & every pixel information from Time domain to freq domain (by using DWT convert transform coefficents)

Step-4:- Those (non integer value) value freq domain coefficients will be quantized

Ex:- $12.48 \xrightarrow{\text{quantized}} 13.$

(Rounded off to 13)

STEP5:- In order to ~~Objec~~ obtain compression use huffman coading. (i.e Reducing the Number of bits).

Applications:-

↳ Applications Related to Web browsing (Internet purpose)