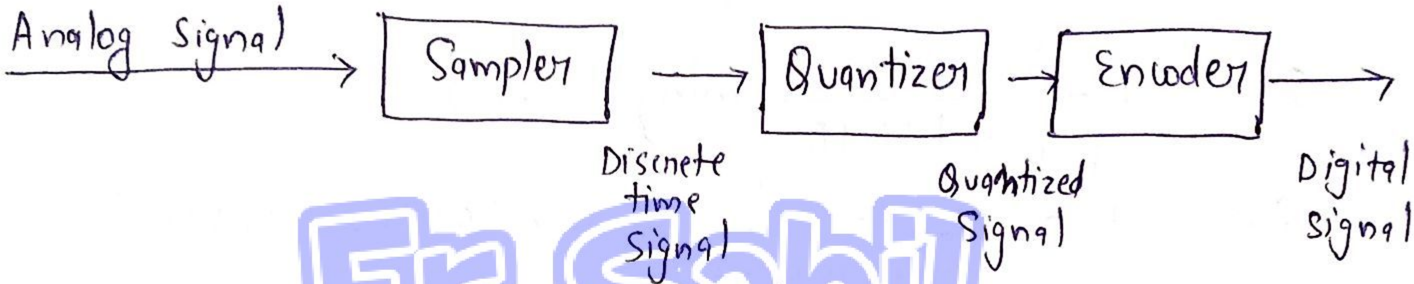
section - (1)

Ans - (b) Sampling ⇒ To convert analog image into digital image we have two intermediate steps. Digitizing the coordinates value (x,y) is called Sampling. And digitizing the amplitude values (F) is called Quantization.



Quantization is the process of converting a continuous analog signal into a digital representation of this signal.

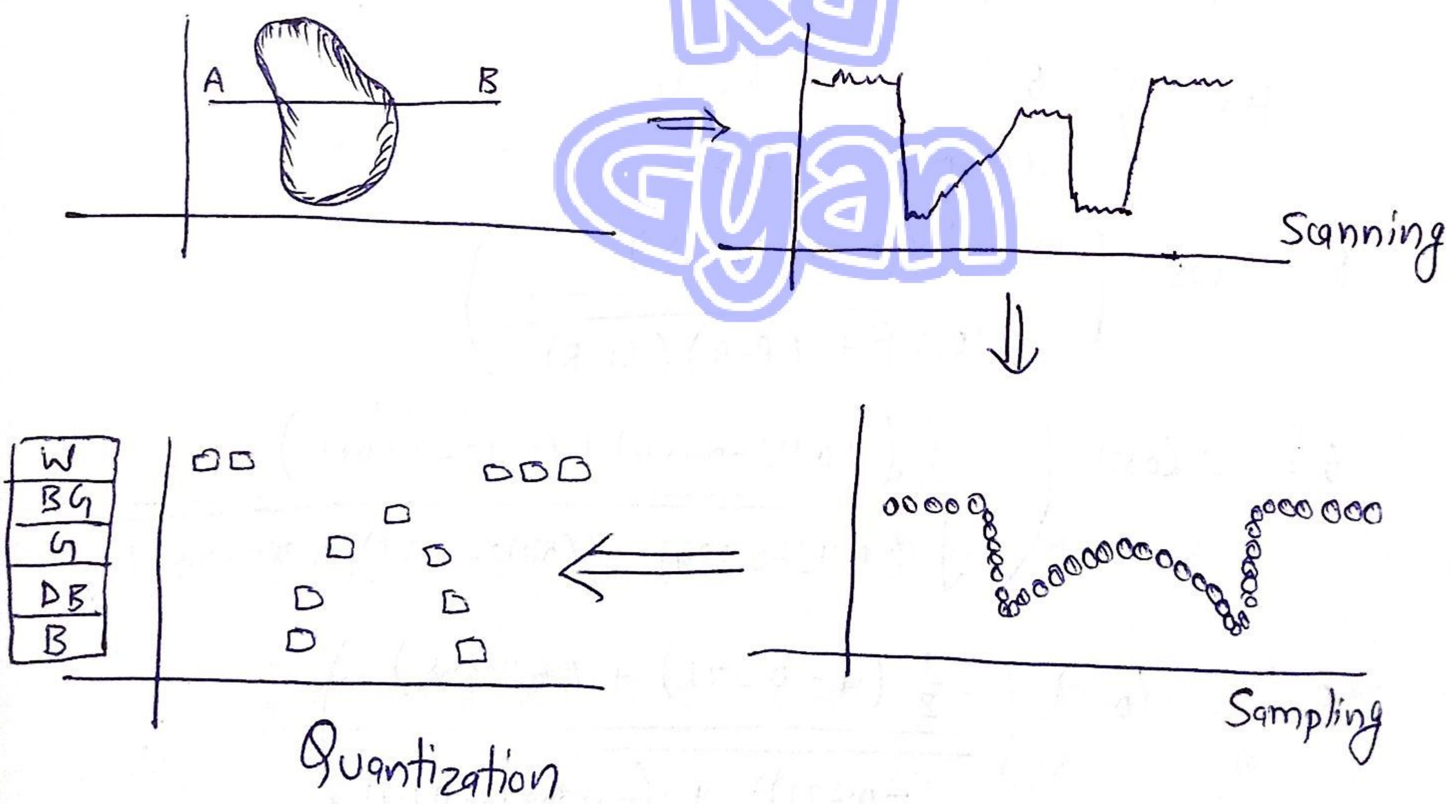


fig :- Sampling & Quantization

(d) Given

$R = 29, \quad G = 98, \quad B = 128$

$R = \frac{29}{255} = 0.113, \quad G = \frac{98}{255} = 0.384, \quad B = \frac{128}{255} = 0.501$

RGB to HSI conversion:-

$I = \frac{1}{3}(R+G+B) = \frac{1}{3}(0.113 + 0.384 + 0.501)$

$I = \frac{0.998}{3} = 0.332 \quad \boxed{I = 0.332}$

$S = 1 - \frac{3}{R+G+B} \min(R, G, B)$

$S = 1 - \frac{3}{0.113+0.384+0.501} \min(0.113, 0.384, 0.501)$

$S = 1 - \frac{3}{0.998} \times 0.113 = 1 - \frac{0.339}{0.998}$

$S = 1 - 0.339 = 0.661 \quad \boxed{S = 0.661}$

$$H = \begin{cases} \theta^\circ & B <= G \\ 360 - \theta^\circ & B > G \end{cases}$$

$$\theta = \cos^{-1}\left(\frac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{(R-G)^2 + (R-B)(G-B)}}\right)$$

$$\theta = \cos^{-1}\left(\frac{\frac{1}{2}((0.113-0.384)+(0.113-0.501))}{\sqrt{(0.113-0.384)^2 + (0.113-0.501)(0.384-0.501)}}\right)$$

$$\theta = \cos^{-1}\left(\frac{\frac{1}{2}((-0.271)+(-0.388))}{\sqrt{(-0.271)^2 + (-0.388)(-0.117)}}\right)$$

$$\theta = \cos^{-1}\left(\frac{-0.3295}{\sqrt{0.073 + 0.045}}\right) = \cos^{-1}\left(\frac{-0.3295}{\sqrt{0.1183}}\right)$$

$$\theta = \cos^{-1}\left(\frac{-0.3295}{0.3439}\right)$$

$$\theta = \cos^{-1}(-0.958) = 163.33^\circ$$

$\cancel{\theta = 163^\circ}$ $\theta = 163.33^\circ$

$$H = 360^\circ - \theta = 360^\circ - 163.33^\circ$$

$$\boxed{H = 196.67^\circ}$$

(c) An intensity image is a data matrix, I, whose values represent intensities within some range. The intensity 0 usually for Black & 255 or 65535 for white.

Intensity Transformation function :- It is applied on image for contrast manipulation

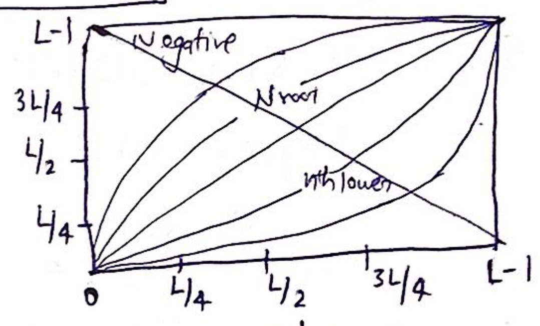
or image thresholding.

(i) Linear Transformation :- It is given by

$$\boxed{S = L-1-r}$$

If $r = 0$, $S = L-1$

If $r = L-1$, $S = 0$

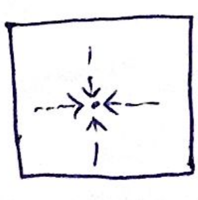


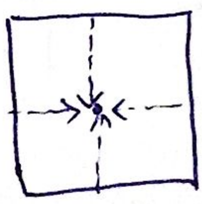
I/O

(ii) <u>Log Transformation :-</u> The general form of this transf is

$\boxed{S = C\log(1+r)}$ where, c is a constant, r≥

→ The shape of log curve in this transformation values ma a narrow range of low intensity values in I/P into a wide range of o/p level.



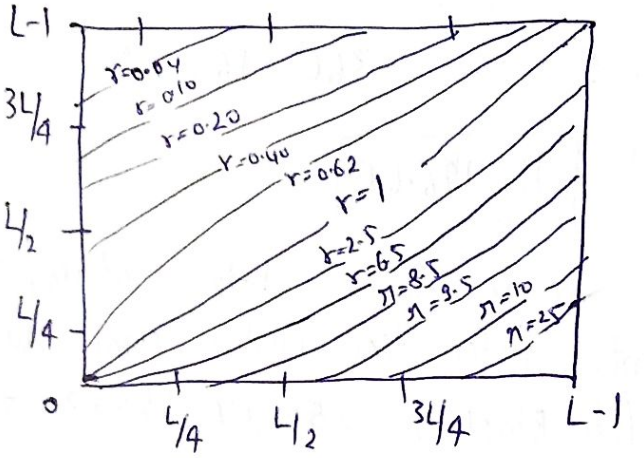


(5) Power Law Transformation:- It is given by $\boxed{s = c r^{\gamma}}$ (3)

if $\gamma = 1$, No change

if $\gamma > 1$, It provides compression of brighter region.

if $\gamma < 1$, it provides expansion of darker region.



Section - (II)

Ay-(5)

(i) Binary Image :-

As we know In Binary image,

1 pixel = 1 bit

$512 \times 512 \times 1 = 512 \times 512$ bit

($\because$ 1 byte = 8 bit)

$$\frac{512 \times 512}{8} = 32768 \text{ byte}$$

($\because$ 1 KB = 1024 byte)

$$\frac{32768}{1024} = 32 \text{ KB}$$

($\because$ 1 MB = 1024 KB) $\Rightarrow \dfrac{32}{1024} = 0.03125$ MB

(ii) Gray Image:- We know that

1 pixel = 8 bit

$512 \times 512 \times 8$ bit

In byte, $\frac{512 \times 512 \times 8}{8} = 264144$ byte

In KB, $\frac{264144}{1024} = 256$ KB

In MB, $\frac{256}{1024} = 0.25$ MB

(iii) RGB Image :- We know that

1 pixel = 24 bit

So $512 \times 512 \times 24$ bit $= 6291456$ bit

In byte, $\frac{6291456}{8} = 786432$ byte

In KB, $\frac{786432}{1024} = 786$ KB

In MB, $\frac{786}{1024} = 0.75$ MB

Ay - (2) Steps in Digital Image processing :-

(i) Image Acquisition :- The image is captured by a sensor & digitized if o/p of camera or sensor is not already in digital form, using analog to digital converter.

(ii) Image Enhancement :- The process of manipulating an image so that result is more suitable than original for specific application.

(iii) Image Restoration :- Improving the appearance of an image.

(iv) Color Image Processing :- It Uses color of image to subtract features of interest in an image.

(v) Wavelets :- Foundation of representing in various degree of resolution.

(vi) Compression:- Techniques for reducing storage required to save an image.

(vii) Morphological:- Tools for extracting image components that are useful in representation of shape.

(viii) Image Segmentation:- It procedures partition an image into its constituent parts.

(ix) Knowledge Base:- knowledge about a problem domain is cooled into an image processing

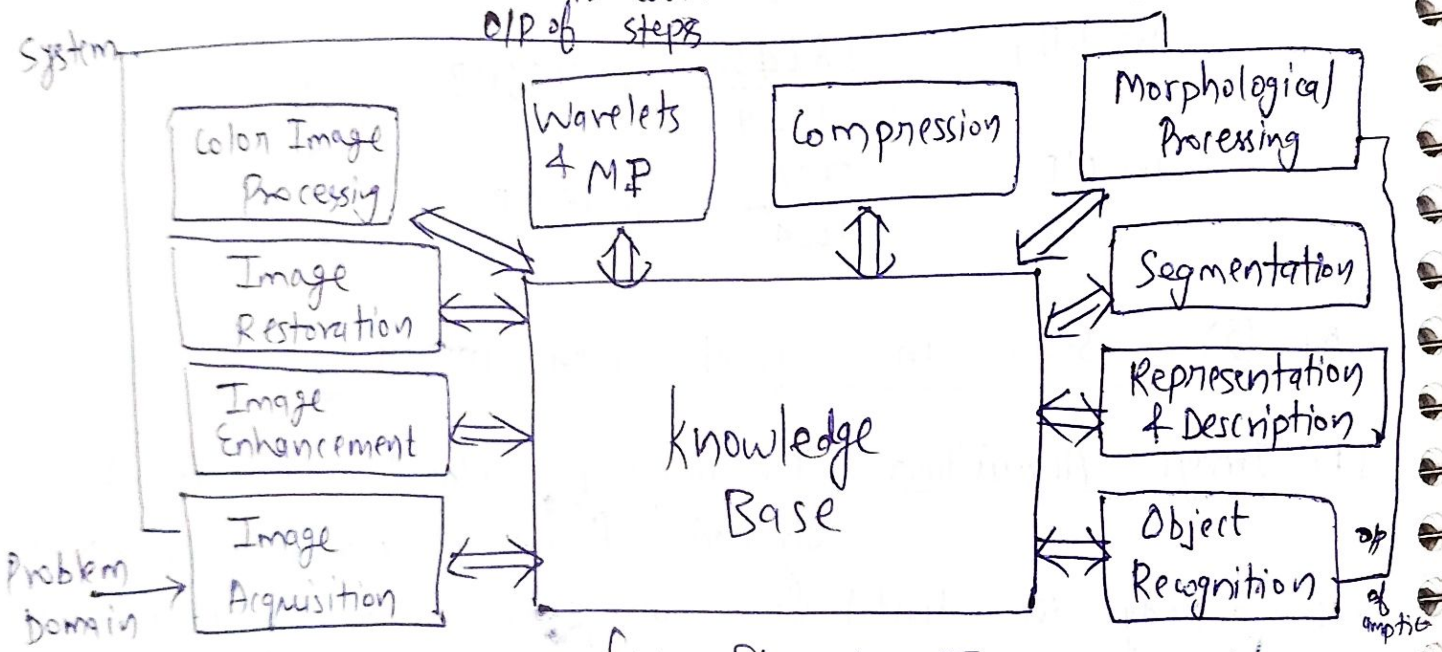


fig:- Steps in Image processing.

Section-1

(d) $R = \frac{29}{255} = 0.114$

$G = \frac{98}{255} = 0.384$

$B = \frac{128}{255} = 0.502$

As we know that

$C = \text{Blue} + \text{Green}$

$C = 0.502 + 0.384 \Rightarrow 0.886$

$\boxed{C = 0.886}$

$M = \text{Red} + \text{Blue}$

$M = 0.114 + 0.502 = 0.616$

$\boxed{M = 0.616}$

$Y = \text{Green} + \text{Red}$

$Y = 0.384 + 0.114 = 0.498$ $\boxed{Y = 0.498}$

$\boxed{\cancel{Y = 0.498}}$

If $RGB = (0.113, 0.384, 0.501)$

then

$C, M, Y = (0.886, 0.616, 0.498)$

Section - 2

A - 3 <u>Sampling:-</u> The process of digitizing coordinate values is called sampling.

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

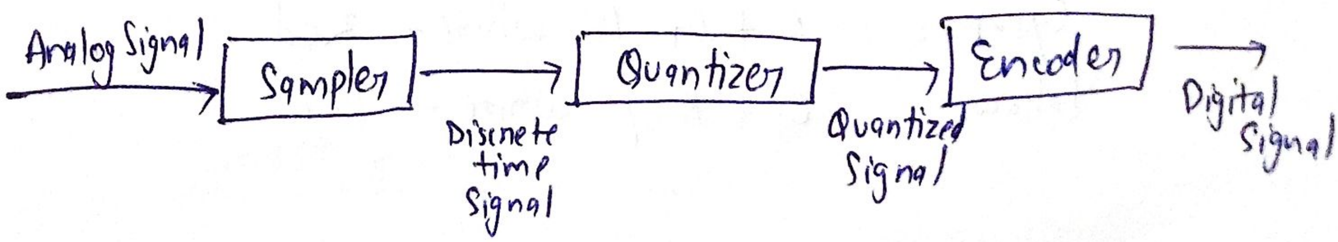
Sampling rate of digitizer determines spatial resolution of digitized image.

<u>Quantization:-</u> The process of digitizing amplitude values is called Quantization.

Magnitude of sample Image is expressed as digital values.

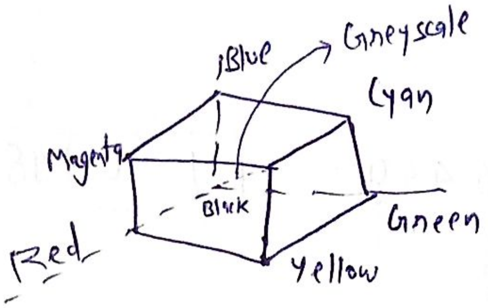
If b-bits are used

$k = 2^b$ 8 bit/pixel



Ay-(4) Types of color Model

RGB :- Each color appears in primary components of red, green & Blue. This model is based on carterian cordinate system.



CMY :- This model contains secondary colors. In this model any secondary color when passed through white light will not reflect color from combination of color is made.

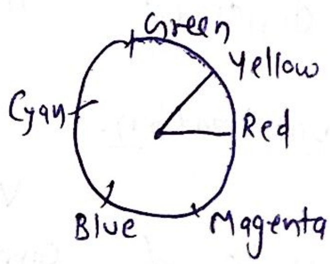
$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

HSI :- Hue :- It is color component that describes pure color.

$0° \rightarrow R$, $120° \rightarrow G$, $240° \rightarrow B$, $60° \rightarrow$ Yellow, $360° \rightarrow$ Magenta

Saturation :- The measure of degree to which color is mixed with the color.

Intensity :- Range is $[0, 1]$



Conversion of colors Model :-

Magneta = R + B / white Green
Cyan = B + G / white - Red
Yellow = G + R / White - Blue

(a) Inverse Filtering:- It is to recover the original image from the blurred image.

We explore 2 methods of inverse filtering -

→ A Thresholding Method

→ An Iterative Method

Method 1: Thresholding ⇒

$$g(n_1, n_2) = f(n_1, n_2) ** b(n_1, n_2)$$

$$f(n_1, n_2) = g(n_1, n_2) ** h(n_1, n_2)$$

Method 2: Iterative :-

$$f_0(n_1, n_2) = \lambda g(n_1, n_2)$$

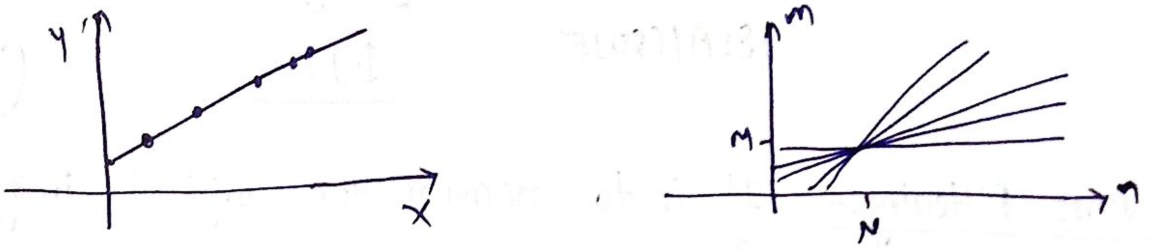
$$\hat{f}_{k+1}(n_1, n_2) = \hat{f}_k(n_1, n_2) + \lambda [g(n_1, n_2) - \hat{f}_k(n_1, n_2) ** b(n_1, n_2)]$$

$$\hat{f}_k = \lambda G(\omega_1, \omega_2)[1 + (1 - \lambda B(\omega_1, \omega_2)) + \cdots (1 - \lambda B(\omega_1, \omega_2)^k)]$$

$$= \frac{G(\omega_1, \omega_2)}{B(\omega_1, \omega_2)} [1 - (1 - \lambda B(\omega_1, \omega_2))^{k+1}]$$

(e) Hough Transform is a feature extraction technique used in image analysis, computer vision, & digital image processing. The purpose of tech. is to find imperfect instances of objects within a certain class of shapes by a voting procedure.

2



Hough Transform

(b) The search Based methods detect edges by first computing a measure of edge strength, usually a first order derivative expression. such as the gradient magnitude & then searching for local directional maxima of the gradient magnitude using a computed estimate of the local orientation of the edge, usually the gradient.

$$f(x,y) = \frac{f(x+h,y) - f(x-h,y)}{2h} \Rightarrow \begin{array}{|c|c|c|}\hline -1 & 0 & 1 \\ \hline\end{array}$$

$$f(x,y) = \frac{f(x,y+h) - f(x,y-h)}{2h} \Rightarrow \begin{array}{|c|}\hline -1 \\ \hline 0 \\ \hline 1 \\ \hline\end{array}$$

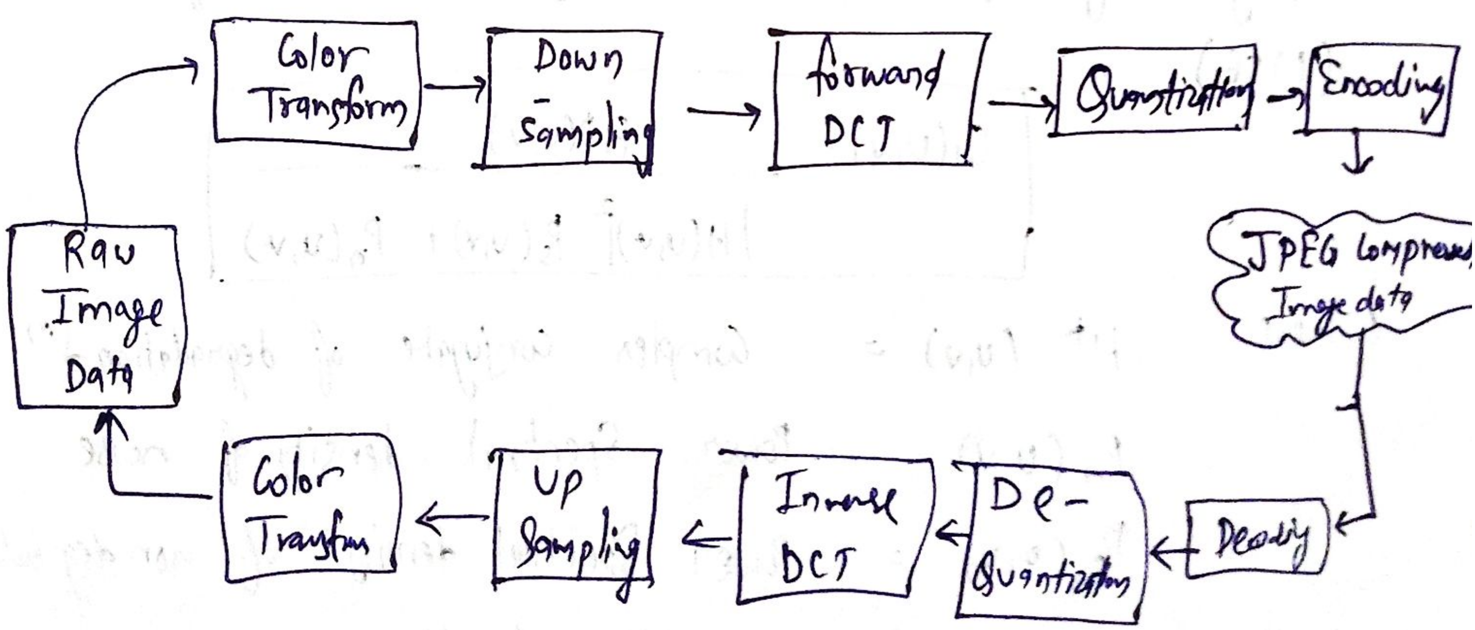
(c) Arithmetic Coding :- It is a form of entropy encoding used in lossless data compression. Normally, a string of characters such as the words "hello there" is represented using a fixed no of bits per character, as in the ASCII code.

It encodes an entire file as a sequence of symbols. (3)
The i/p symbols are processed one at each iteration. The initial interval [0,1] or [1,0] is successively divided into subintervals on each iteration according to the probability distribution.

(d) <u>JPEG compression</u>:- JPEG uses a lossy form of compression based on discrete cosine transform (DCT).

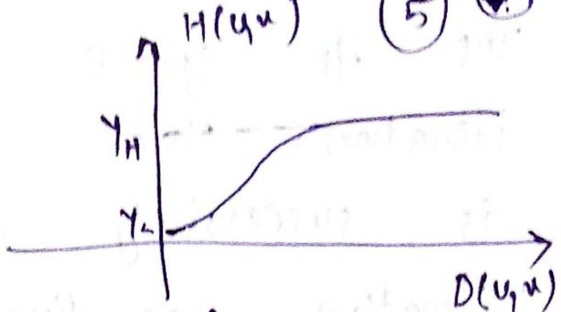
→ The degree of compression can be adjusted allowing a tradeoff b/w storage size & image quality with compression ration 10:1 but with little perceptible loss in image quality.

→ This converts each frame of video source from the spatial (2D) domain into frequency domain.



<u>JPEG Compression</u>

(b) Homomorphism filtering →



(5)

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

$0 < i(x,y) < \infty$ $\quad$ $0 < r(x,y) < 1$

In: $z(x,y) = \ln f(x,y) = \ln i(x,y) + \ln r(x,y)$

DFT: $Z(u,v) = F_i(u,v) + F_r(u,v)$

H(u,v): $S(u,v) = H(u,v)\, Z(u,v)$

$(DFT)^{-1}$: $s(x,y) = i'(x,y) + r'(x,y)$

exp : $g(x,y) = e^{s(x,y)} = i_0(x,y)\, r_0(x,y)$

$f(x,y) \Rightarrow \boxed{\ln} \rightarrow \boxed{DFT} \rightarrow \boxed{H(u,v)} \rightarrow \boxed{(DFT)^{-1}} \rightarrow \boxed{exp} \Rightarrow g(x,y)$

Wiener filter :- The purpose of Wiener filter is to filter out the noise that has corrupted a signal.

→ This filter is based on a statistical approach.

→ The goal of WF is reduced the mean square Error (MSE)

$$\boxed{G(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 P_s(u,v) + P_n(u,v)}}$$

Where $H^*(u,v)$ = Complex conjugate of degradation f^n

$P_n(u,v)$ = Power Spectral density of noise

$P_s(u,v)$ = Power Spectral density of non degraded

$H(u,v)$ = Degradation function.

(d) Thresholding :- It is the process of creating black & white image out of gray scale image by setting exactly those pixels to white whose value is above a given threshold, setting other pixels to Black. ⑥

Grayscale Image by thresholding can be used to create binary images.

Types of thresholding methods :-

(i) Threshold Binary :-

$$dst(x,y) = \begin{cases} maxVal & \text{if } src(x,y) > thresh \\ 0 & \text{otherwise} \end{cases}$$

value = value > threshold ? maxVal : 0

(ii) Threshold Binary, Inverted :-

$$dst(x,y) = \begin{cases} 0 & , \text{otherwise} \\ maxVal & \text{if}(src(x,y) > thresh \end{cases}$$

value = value > threshold ? 0 : maxVal

(iii) Truncate :-

$$dst(x,y) = \begin{cases} threshold & , \text{if } src(x,y) > thresh \\ src(x,y) & , \text{other} \end{cases}$$

(iv) Threshold to Zero :-

$$dst(x,y) = \begin{cases} 0 & , \text{if } src(x,y) > thresh \\ maxVal & , \text{otherwise} \end{cases}$$

(v) Threshold to Zero, inverted :-

$$dst(x,y) = \begin{cases} src(x,y) & , \text{if } src(x,y) > thresh \\ 0 & , \text{otherwise} \end{cases}$$

value = value ? threshold ? 0 : value

(e) Point Detection :- • This is used to detect isolated spots in an image.

- The graylevel of an isolated point will be very different from its neighbors. (7)

•
$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

- The o/p of mask operation is usually thresholded.

•
$$|8f_5 - (f_1 + f_2 + f_3 + f_4 + f_6 + f_7 + f_8 + f_9)| > T$$

Detection of Lines :- • This is used to detect lines in an image.

- This can be done using the following four masks:-

$$D_0 = \begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix}$$ Horizontal lines

$$D_{45^\circ} = \begin{bmatrix} -1 & -1 & 2 \\ -1 & 2 & -1 \\ 2 & -1 & -1 \end{bmatrix}$$ 45° lines

$$D_{90^\circ} = \begin{bmatrix} -1 & 2 & -1 \\ -1 & 2 & -1 \\ -1 & 2 & -1 \end{bmatrix}$$ 90° Lines

$$D_{135^\circ} = \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$ 135° lines

Section-(3)

(a) Image Compression ⇒ It is the process of encoding or converting an image file in such a way that it consumes less space than the original file.

→ It is type of compression technique that reduces the size of an image file without affecting or degrading its quality to a greater extent.

Some of common image compression techniques are:-

- Fractal
- Wavelets
- Chroma sub Sampling
- Transform coding
- Run-length Encoding

8

Types of Image Compression:-

(i) Lossless Technique ⇒ In loss tech. with compressing of data that is when get decompressed will be the same replica of actual data.

These types of compression are also known as noiseless as they never add noise to signal or image.

(ii) Lossy Technique:- It decreases the bits by recognizing the not required info and by eliminating it. The system of decreasing the size of data is commonly termed as data-compression, though it formally name as source coding.

→ Lossless

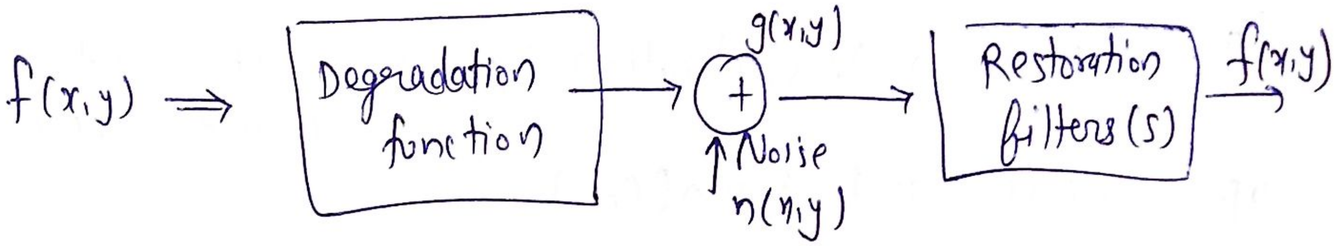
- Runlength
- Huffman
- Shannofano
- Arithmetic

→ Lossy

- JPEG
- MPEG
- Block transform
- Lossy predictive

Ay-(6)

Image Degradation:- The degradation process for an image uses a degradation function together with an additive noise term. (8)



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

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

Image Restoration:- Goal of restoration technique is to improve an image in some predefined sense.

Restoration attempts to reconstruct or recover an image that has been degraded by using a prior knowledge of degradation phenomenon.

Section - (1)

(e) **Noise Models:-**

(i) **Gaussian Noise** ⇒ It is statistical noise having a probability density function equal to normal distribution.

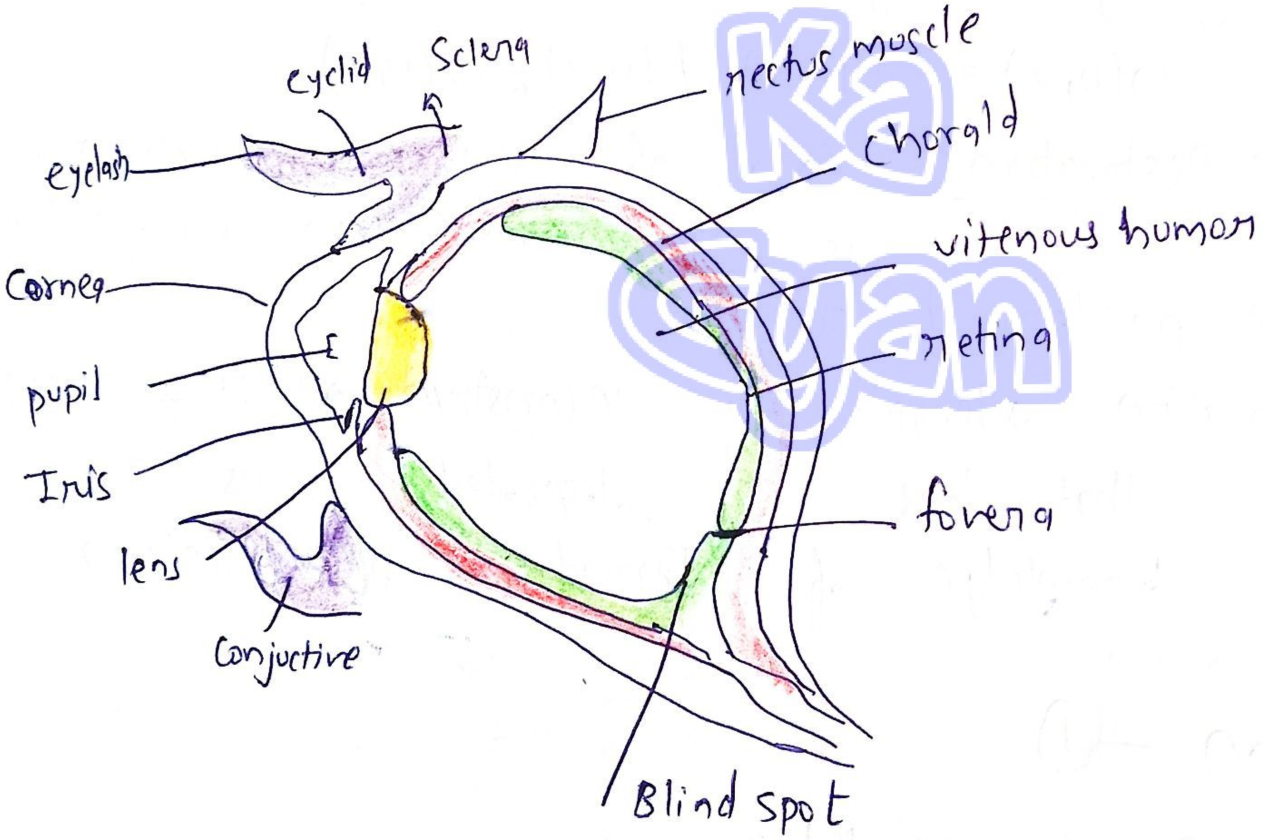
$$\boxed{p = \frac{1}{\sqrt{2\pi}\,\sigma} e^{(z-u)^2/2\sigma^2}}$$

(ii) **Impulse Noise:-** In discrete world impulse function on a value of 1 at a single location. There are 3 types of noises:- Salt, Pepper & Salt & pepper noise

(iii) Poisson Noise:- The appearance of noise is seen due to statistical nature of EMW such as X-rays, visible lights & gamma rays.

(9) Human Visualization System:- It consists mainly of the eye (camera), optic nerve and brain (CPU).

It is sophisticated image process.



Vertical section of eye.