Digital Image Processing (NCS-801)

74

Unit - 1

Introduction & Fundamentals

Motivation & Perspective, Applications, Component of image processing system, Element of visual perception, A simple image model, sampling & Quantization.

Image Enhancement in Frequency Domain

Fourier transform and the Frequency Domain, Basis of Filtering in Frequency Domain, Filters - Low pass, High pass; correspondence b/w filtering in spatial & frequency Domain smoothing Frequency Domain filters - Gaussian Low pass filters; sharpening Frequency Domain Filters - Gaussian Highpass Filters; Homomorphic filtering

---

Image: An image is defined as 2D function, $f(x,y)$, where x & y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x,y) is called the intensity or gray level of the image at that point.

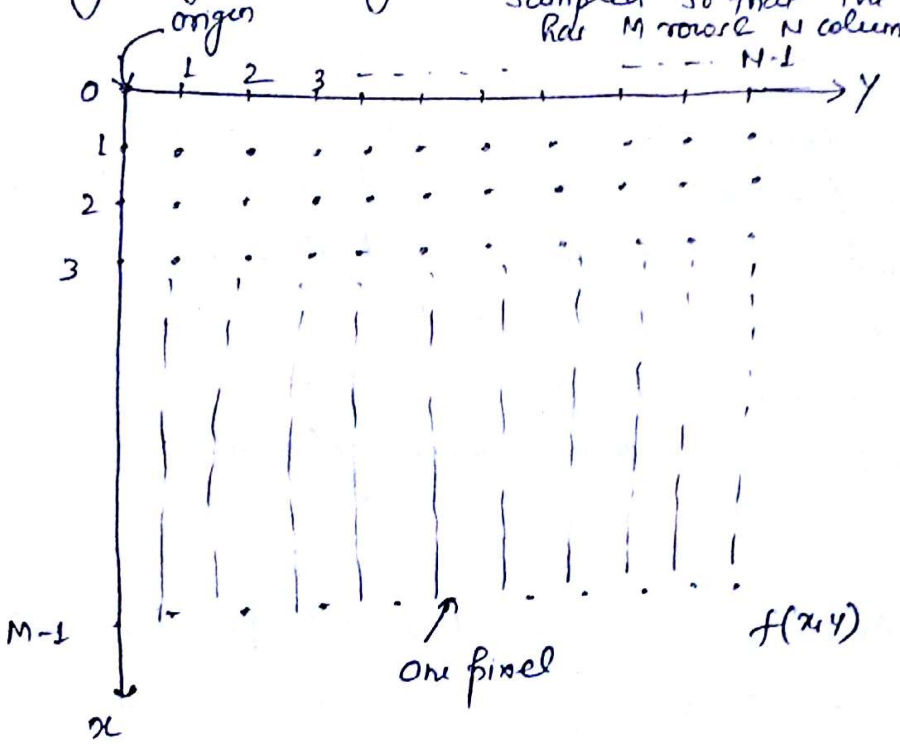
When x, y and the amplitude values of f are all finite, discrete quantities, then the image is known as digital image.

The processing of digital image by means of computer refers to Digital image processing.

NOTE: A digital image is composed of a finite number of elements, each of which has a particular location and values. These elements are referred to as a picture elements, image elements, pels and pixels

Pixel is the smallest unit of the digital image.

Representing Digital images: Assume that an image f(x,y) is sampled so that the resulting image has M rows & N columns.



Coordinate convention used to represent digital image

spatial coordinates that uses x to refers to columns & y to refers to rows.

Image as matrices:

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

The right ~~sig~~ side of this eqn is a digital image by definition.

each element of this array is called an image element, or pixel.

Digital image representation as a MATLAB matrix.

$$f = \begin{bmatrix} f(1,1) & f(1,2) & \text{---} & f(1,N) \\ f(2,1) & f(2,2) & \text{---} & f(2,N) \\ \vdots & & & \\ f(M,1) & f(M,2) & \cdots & f(M,N) \end{bmatrix}$$

MATLAB functions :

Read the image : imread ('filename')

>> f = imread (deepak. jpg) ;

read the image from JPEG file into image array f

Begining of command line

Display the image

imshow (f)

To keep the first image & o/p a second image use function

>> figure , imshow(g)

Write the image : Images are written to the current directory using function imwrite ,

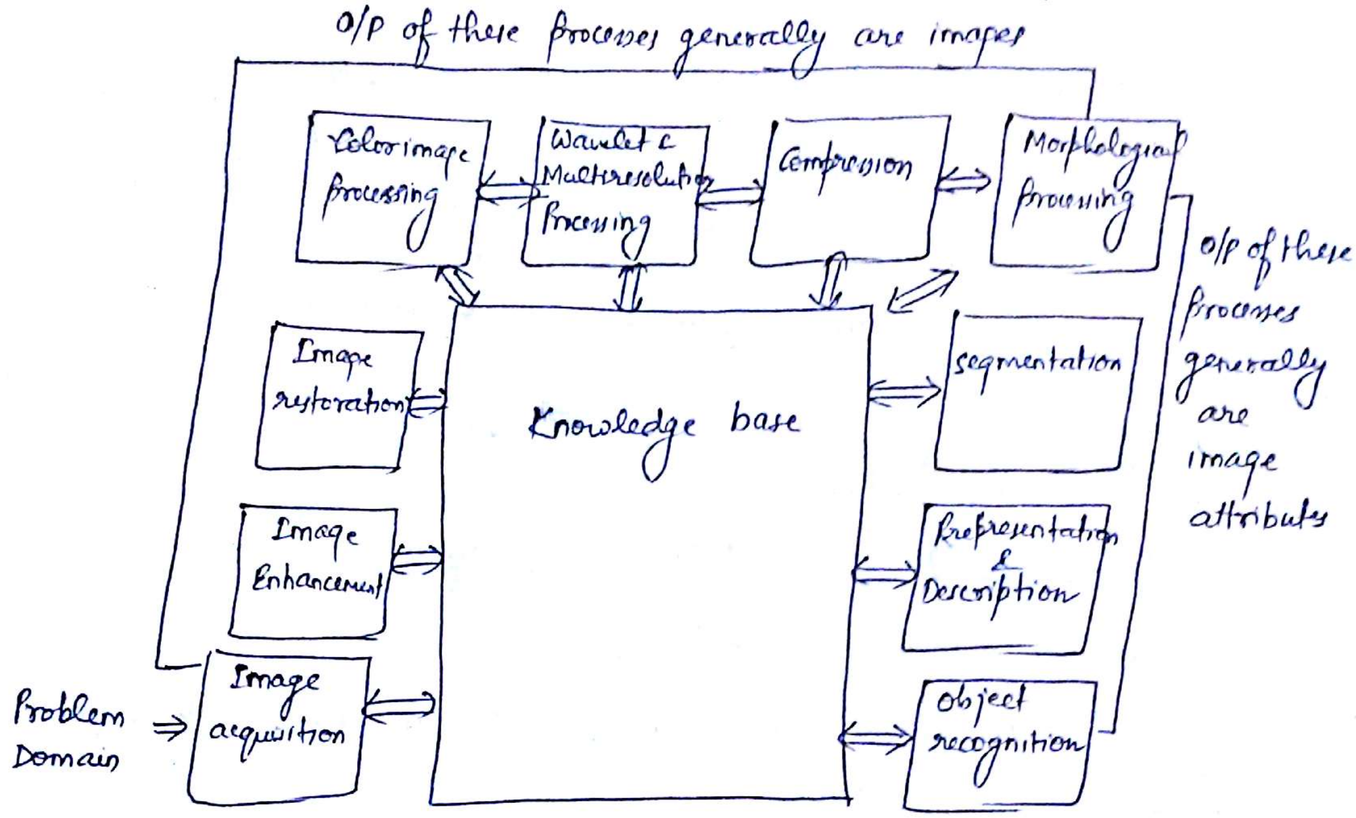
imwrite (f, 'filename')

imwrite (f, 'filename . jpg', 'quality', q)

q = 0 to 100

v. Imp

Fundamental steps of Digital image processing:-



Wavelet & multiresolution Processing :-

wavelets are the foundation for representing images in various degrees of resolution.

Morphological processing : It deals with tools for extracting image components that are useful in the representation & Description of shape.

Recognition : It is the process that assigns a label ("vehicle") to an object based on its descriptions.

Components of an image processing system:

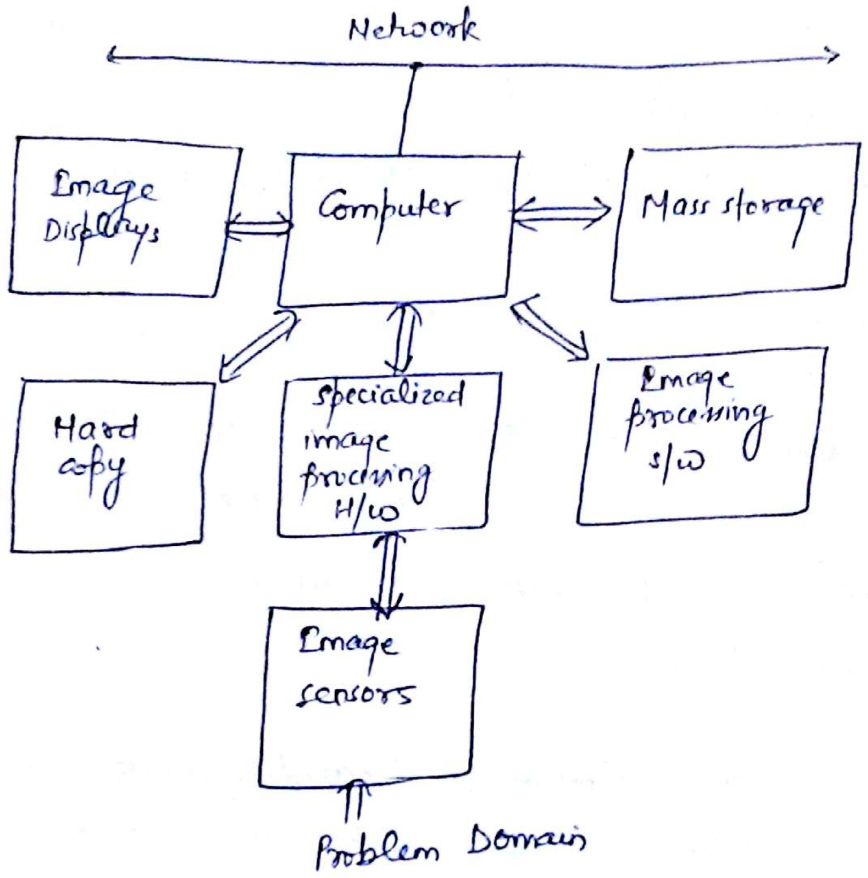


Image processing H/w It consist of digitizer plus H/w that performs other primitive operations such as an arithmetic logic unit (ALU) which perform arithmetic & logical operations in parallel on entire images as quickly as image digitized, for the ex. image averaging for the purpose of noise reduction

Computer
- General purpose computer (Range from PC to a supercomputer)
- specially designed computer

S/w It consist of specialized modules that perform specific tasks. A well designed package also include the capability for the user to write code that, as a minimum, utilizes the specialized modules

Mass storage : Digital storage for image processing application falls into 3 principal categories-

Short term storage for use during processing
Online storage for relatively fast re-call
Archival storage. characterized by infrequent access.

Image display : Color TV monitors

Hard copy devices : For recording images include laser printers, film cameras, heat sensitive devices. ~~injekt~~ inkjet units, & digital units such as optical & CD Rom. disks.

Networking : It is almost a default function in any computer system. Because the large amount of data inherent in image processing applications, the key consideration in image transmission is bandwidth.

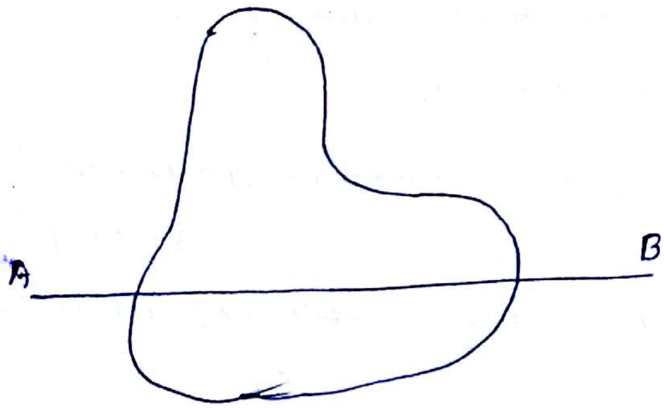
v.v.imp

Image sampling and quantization process :-

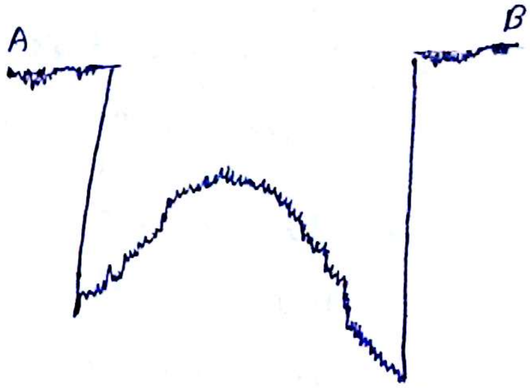
The o/p of most sensor is a continuous voltage waveform whose amplitude and spatial behavior are related to physical phenomenan being sensed. To create a digital image, we need to convert the continuous sensed data into digital form. this involve two processes-

sampling (Digitizing the coordinate values)
Quantization (Digitizing the amplitude values)

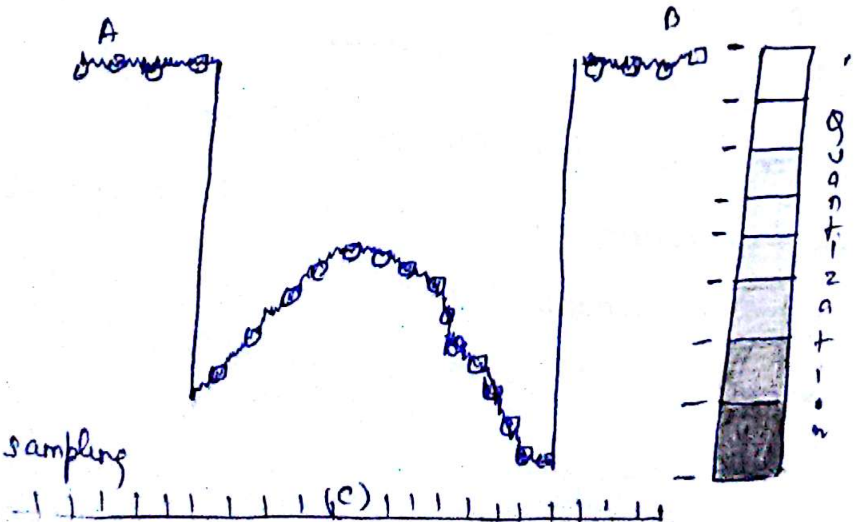
Basic concept in sampling & Quantization:



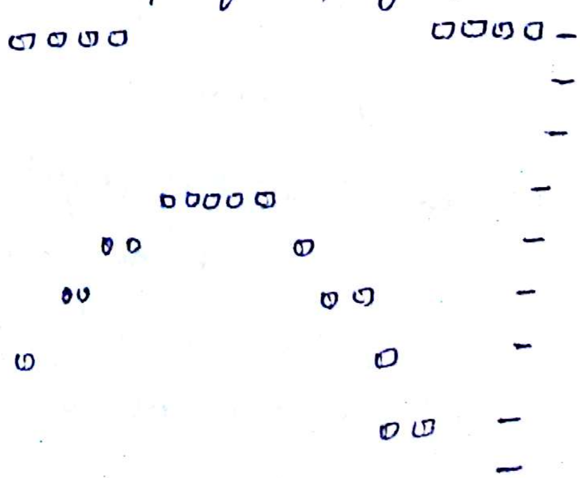
(a) Continuous image



(b) Scan line from A to B in continuous image, used to illustrate the concept of sampling & quantization



(c) Sampling & Quantization



(d) Digital scan line

fig(a) shows continuous ~~alg~~ image along the line segment AB

fig(a) shows a continuous image, $f(x,y)$, that we want to convert to digital form. To convert it to digital form, we have to sample the function in both coordinates and in amplitude.

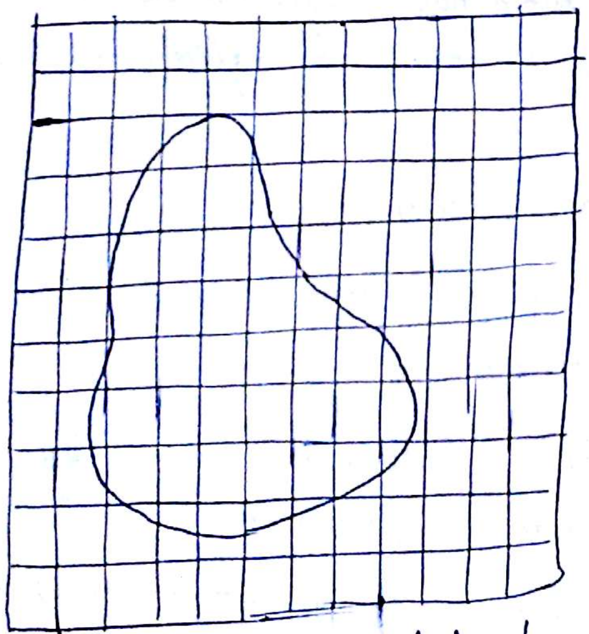
- Digitizing the coordinate values is called sampling.
  Digitizing the amplitude values is called quantization
- 1-D function shown in (b) is a plot of amplitude (gray level) values of the continuous image along the line segment AB. The random variation are due to noise.
- To sample this function, we take equally spaced samples along line AB as shown in (c).
- The location of each sample is given by a vertical tick mark in the bottom part of the figure. The samples are shown as small white squares superimposed on the the function.
- The set of these discrete locations gives the sampled function. However the values of the samples still span (vertically) a continuous range of gray level values
- To form a digital function, the gray level values also must be converted (quantized) into discrete quantities. The right side of fig(c) shows the gray level scale divided into 8 discrete levels ranging from black to white.

⇒ The vertical tick mark indicate the specific value assigned to each of the 8 gray levels The continuous gray levels are quantized simply by assigning one of the 8 discrete levels to each sample.

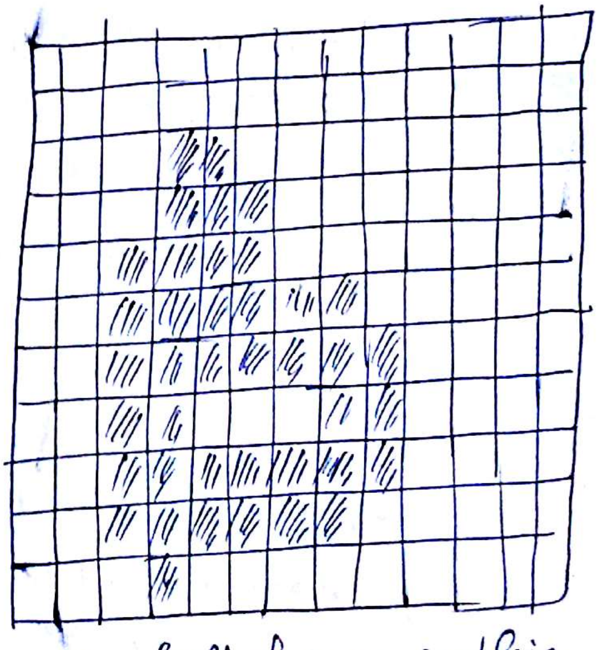
⇒ The assignment is made depending on vertical proximity of a sample to a vertical tick mark.

The digital samples resulting from both sampling & quantization are shown in fig (d).

Starting at the top of image andcarrying out this procedure line by line produces a 2-D digital image



a) Continuous image projected onto a sensor array)



b) Result of image sampling & quantization

Simple image model :-

An image can be represented by 2D functions of the form $f(x,y)$. The value of f is known as amplitude or intensity.

When an image is generated from a physical process, its intensity values are proportional to energy radiated by a physical source (eg Electromagnetic waves).

$f(x,y)$ must be non zero and finite, i.e

$$0 < f(x,y) < \infty \quad \text{—— (1)}$$

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

1) The amount of source illumination incident on the scene being viewed. This is known as illumination component $i(x,y)$.

2) The amount of illumination reflected by the objects in the scene. This is known as reflectance component $r(x,y)$

so $f(x,y) = i(x,y)\, r(x,y)$

where $0 < i(x,y) < \infty$ —— (2)

& $0 < r(x,y) < 1$ —— (3)

eqn (3) indicates that reflectance is bounded by 0 (total absorption) and 1 (total reflectance).

$i(x,y)$ is determined by the illumination source and $r(x,y)$ is determined by the characteristics of the imaged objects

These expression also applicable to images formed via transmission of the illumination through a medium such as chest x ray.

In this we would deal with transmissivity insted of reflectivity function, but the limits would be the same.

Let the intensity (gray level) of a mono chrome image at any coordinates (x_0, y_0) be denoted by

$$l = f(x_0, y_0)$$

l lies in the range

$$L_{min} \le l \le L_{max}$$

in theory $\left.\begin{array}{l} L_{min} > 0 \\ L_{max} < \infty \end{array}\right\}$

in practical $L_{min} = i_{min}\, r_{min}$

$L_{max} = i_{max}\, r_{max}$

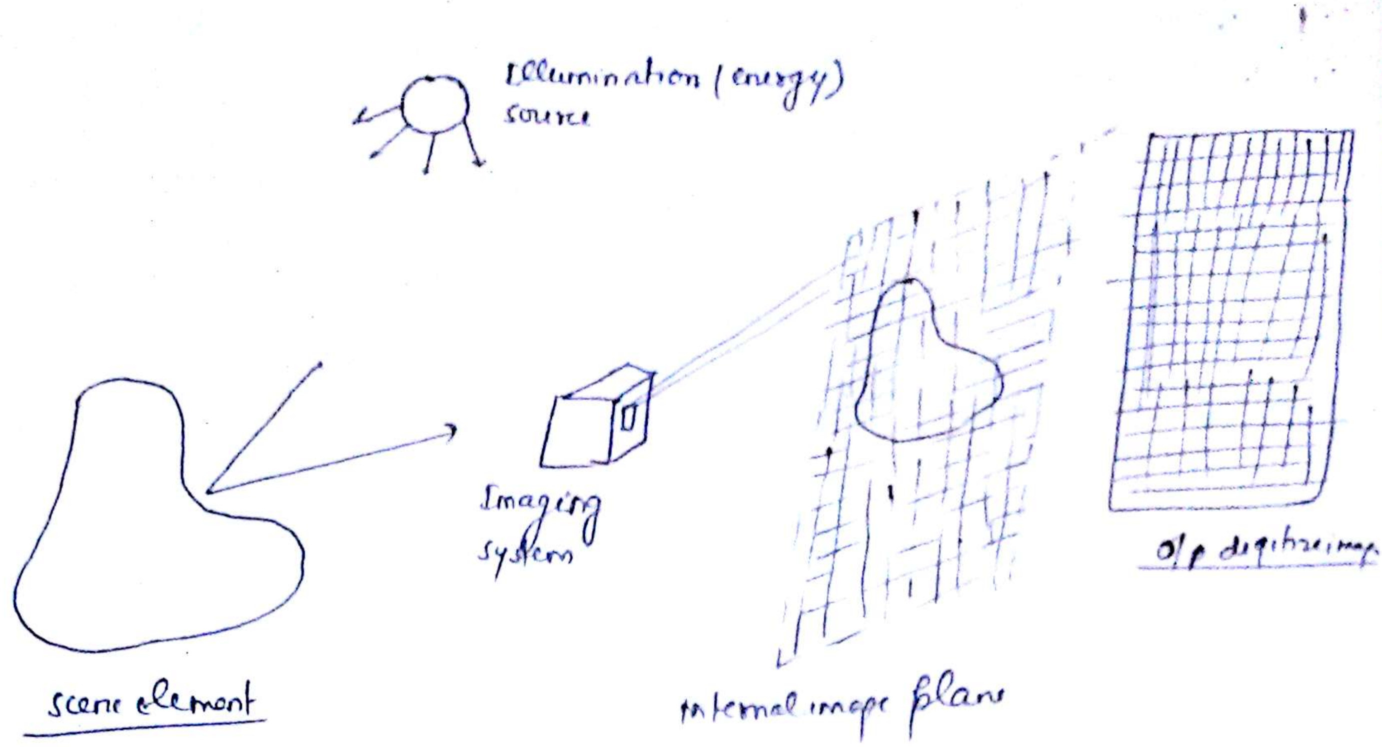
for office illumination $\left.\begin{array}{l} L_{min} \approx 10 \\ L_{max} \approx 1000 \end{array}\right\}$ limit for indoor value in absence of additional illumination

* illumination level in commercial office is about 1000 lm/m2

~~$l = r(x,y)$~~ =

The interval $[L_{min}, L_{max}]$ is called the grayscale.

<u>Elements of visual perception :-</u>



Digital image acquisition

Elements of visual perception :-

1. Structure of the Human Eye
2. Image formation in the Eye
3. Brightness adaptation & Discrimination

Que. If we want to resize a 1024 × 768 image to one that is 600 pixel wide with the same aspect ratio as the original image, what should be the height of the resize image?

$$\text{Aspect ratio} = \frac{\text{width}}{\text{Height}} \Rightarrow \frac{1024}{768} = 1.33$$

$$\text{Height} = \frac{\text{width}}{\text{Aspect ratio}} = \frac{600}{1.33}$$

$$= 451$$

resized image will be 600 × 451

Que: A common measure of transmission for digital data is the baud rate, defined as the number of bits transmitted per second. Transmission is accomplished in packets consisting of a start bit, a byte (8 bits) of information and a stop bit

a) How many minutes would it take to transmit a 1024 × 1024 image with 256 gray levels if we use a 56K baud modem?

b) What would be the time required if we use a 750K baud transmission line?

Physical Resolution :

The number of pixels per unit length is referred to as the resolution of the displaying device.

Thus 3x2 inch image at a resolution of 300 pixels per ince would have total no. of pixels

$(3 \times 300) \times (2 \times 300)$

$= 900 \times 600$

$= 540000$ pixels

Image size = 1024 x 1024 — Width Height — Total no. of pixels in vertical direction

↓

Total no. of pixels in Horizontal direction

Aspect ration : The ration of the image's width to its height, measured in unit length or number of pixels is referred to as its aspect ration.

Ex: 3x3 inch or 128 x 128 image have the aspect ration 1

$$\boxed{\text{Aspect ration} = \frac{\text{Width}}{\text{Height}}}$$

Que. Compute the physical size of a 640 x 480 image when printed by a printer at 240 pixels per inch

$$\left\{ \frac{640}{240} \text{ by } \frac{480}{240} \right\}$$

Scanned by CamScanner

Sol^n

256 gray levels, we need 8 bits for representing each pixel.

along 8 bits. we also have a start bit & stop bit

Hence we have 10 bits per pixel.

Total no. of bits for transmission are

$N = 1024 \times 1024 \times 10$

$= 10485760$ bits

These bits are transmitted at 56 K baud rate.

In 1 sec —— 56K bits

ie 56 K bits —— = 1 sec

$\therefore$ 1 —— $= \frac{1}{56K}$

$\therefore$ 10485760 —— $= \frac{1}{56K} \times 10485760$

$\Rightarrow$ 187.25 sec $\approx$ 3.1 minutes

(b) If the baud rate is 750 K

then time $= \frac{10485760}{750\,K} = \frac{10485760}{750 \times 10^3}$

$\Rightarrow$ 13.98 sec