Digital Image Processing
MODULE 1

By
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Introduction

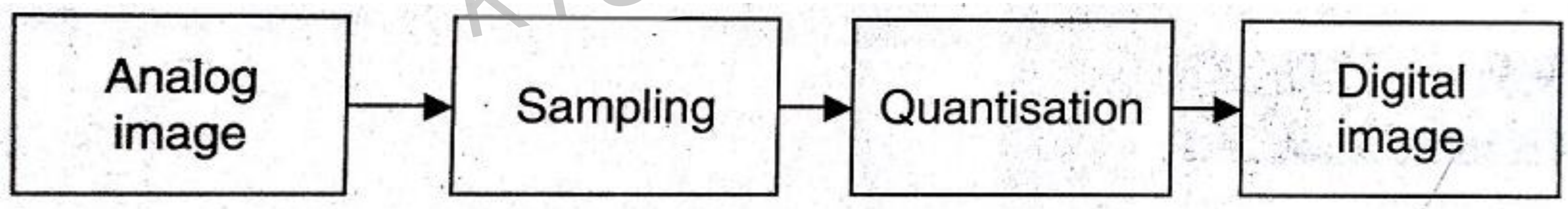
Image

Image ***f(x,y)*** is a projection of a **3D scene** to a **2D projection plane**. An analog image is characterized by physical magnitude varying continuously in space.

e.g: - Image produced on a CRT monitor

Digital Image

Characterized by ***Pixel-*** It is the brightness at one point



Digital image from analog image

Introduction

Advantages of Digital Image

- Faster and cost effective
- Effectively stored and transmitted
- Quality can be analyzed at the time of shooting(capturing)
- Copying is easy and quality will not be degraded
- Reproduction of image is faster and cheaper
- Digital technology offers versatile image manipulations

Drawbacks of Digital Image

- Misuse of copyright
- Enlargement (zoom) is limited by resolution
- Quality and storage memory shows a trade off (inversely proportional)
- High quality processor is required for real time processing

Introduction

Digital Image Processing

Altering the parameters of a digital image using a computer/processor is called DIP

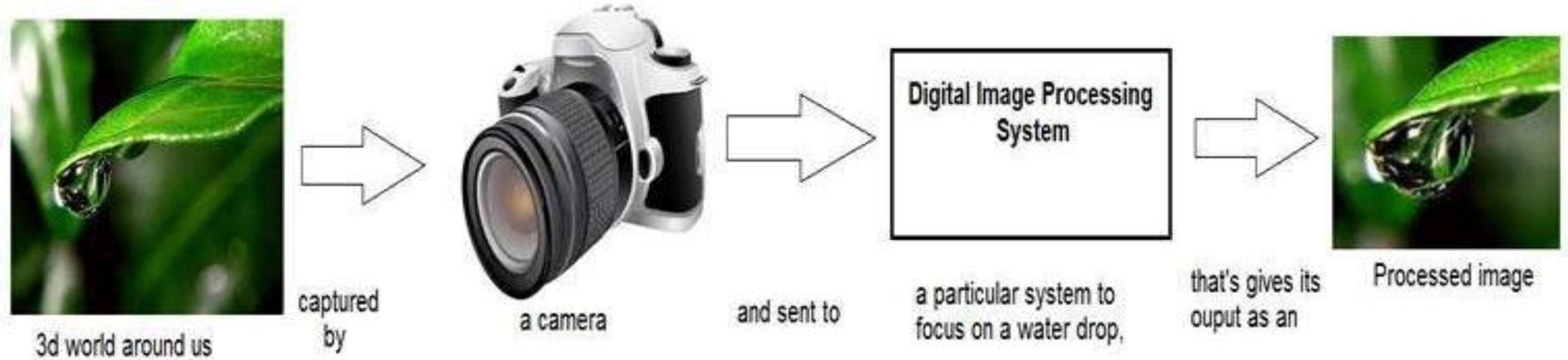
Advantages of Digital Image Processing

- Flexibility & Adaptability

Since digital can be directly used by computer (No special hardware required-Optical/ADC)

- Effectively stored and transmitted

Computers can store images in various formats and can copy to various devices



Introduction

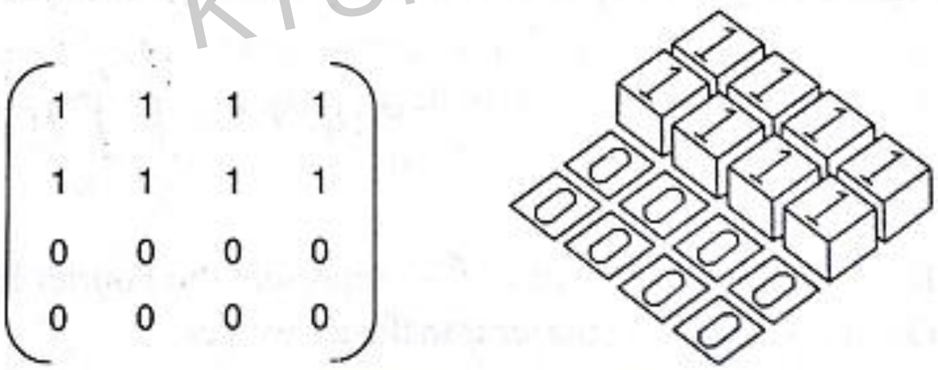
Applications of Digital Image Processing

- Image sharpening and restoration
- Medical field
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Color processing
- Pattern recognition
- Video processing
- Microscopic Imaging
- Others

Introduction

Digital Image Representation

- Is a 2D discrete signal
- Represented by a MXN matrix
- MXN gives resolution by pixel
- Digital camera/scanner can generate a digital image
- Spatial coordinates are determined by sampling
- Allowed intensities by quantization



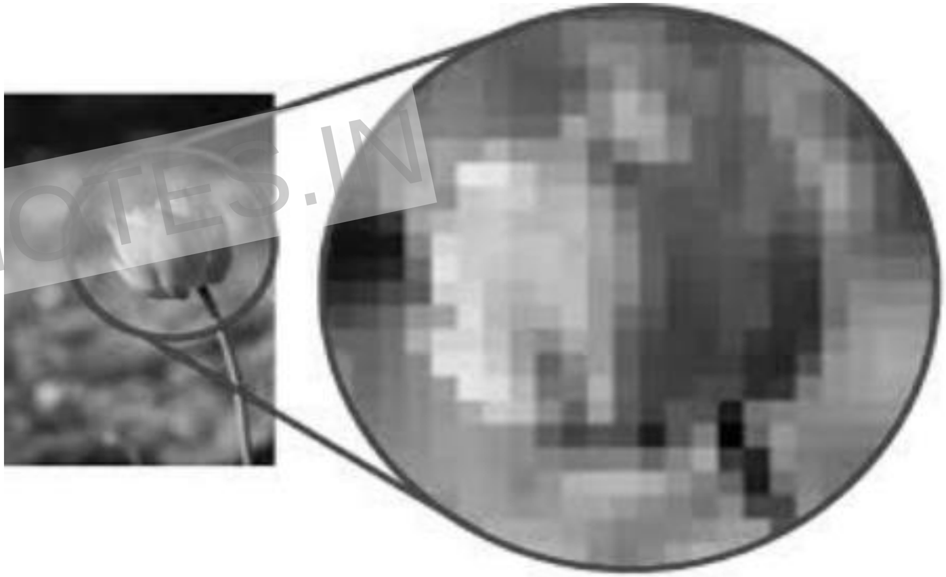
Digital-image representation

Types of Digital Images

1. Raster Image(Bit map image)

- Rectangular arrays of sampled pixels
- Mapped into grids and cannot be scaled easily
- Zooming causes loss of information

e.g: JPEG, TIFF, GIF, PSD, PNG



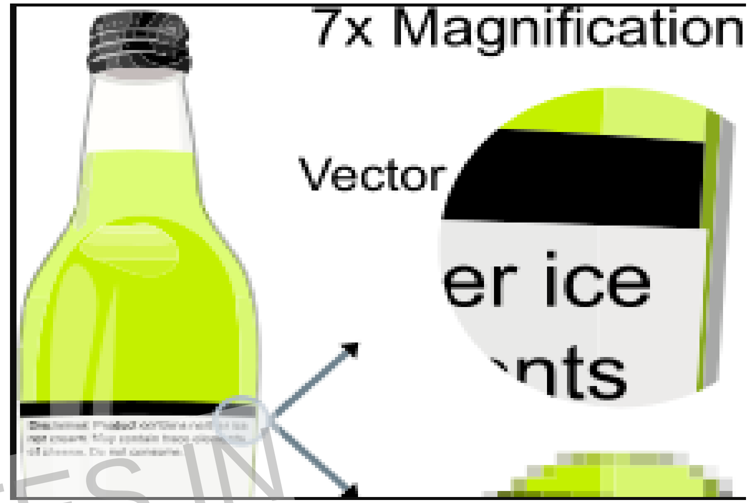
2. Vector Image

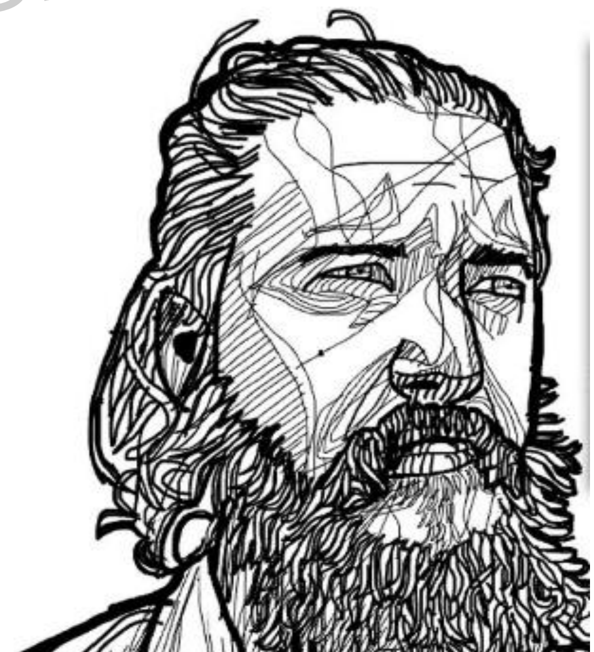
- Made of lines and curves that are mathematically defined
- Synthesized image
- Good zooming possible

Types of Digital Images

2. Vector Image

- Suitable for typography , line art etc

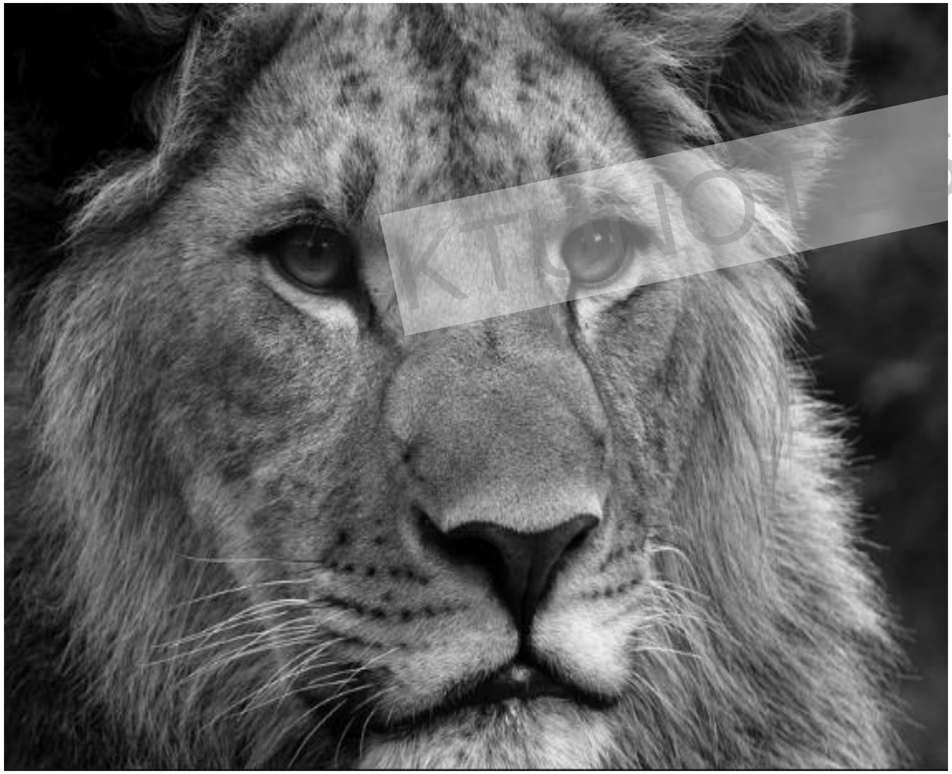




Types of Digital Images

3. Gray scale Image

- They contain only brightness information.
- An 8 bit gray scale image contains 256 brightness levels (0~255)
- 0=black; 255=Pure white.



Types of Digital Images

4. Binary Image (Black & White Image) (Monochrome Image)

- They contain only two levels of brightness. (0 or 1)
- A gray scale image can be converted to binary by using thresholding.
- Binary images are useful in locating geometric parameters like centroid.

Types of Digital Images

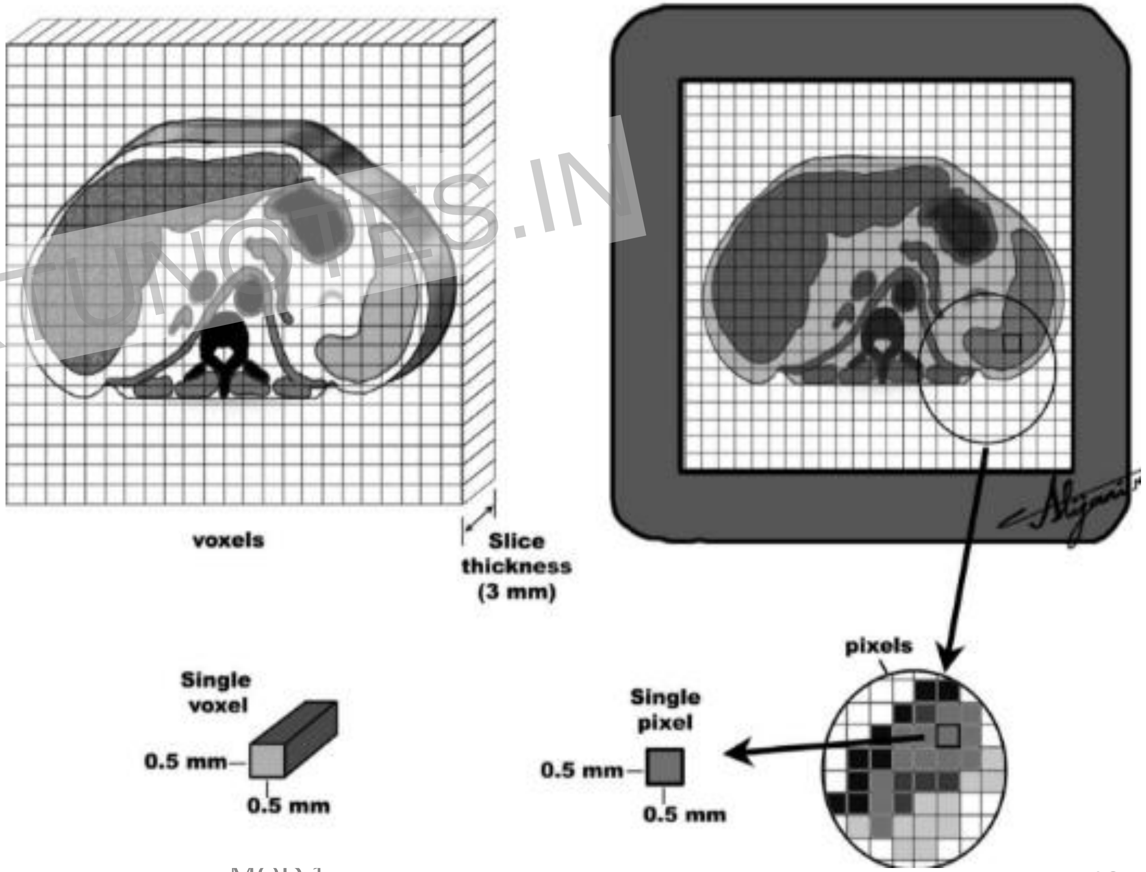
5. Color Image

- Each pixel carry 3 data (Brightness, Intensity & Chrominance of light)
- The pixels are allocated in all available color planes depending on their brightness information
- Eg: in RGB (**Red**, **Green**, **Blue**) format each pixel has a red, green and blue component depending on its brightness.
- HSV (Hue, Saturation, Value) , CMYK (Cyan, Magenta, Yellow, Black)

Types of Digital Images

6. Volume Image

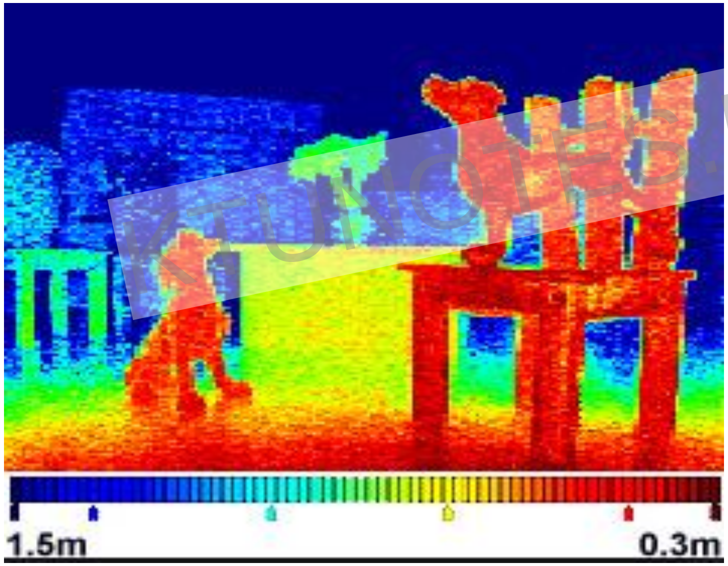
- 3D image containing volume information
- Pixels are called Voxels (Volume + Pixel)
- Eg: CT Scan images



Types of Digital Images

7. Range Image (Depth Image)

- Pixel contains information about the distance from a known reference
- Can be used to reconstruct 3D images



Types of Digital Images

8. Multi spectral image

- Images contains overlapped images of same object in different regions of EM-spectrum
- IR, UV and Visible
- They are partially out side our perception range
- But useful in understanding various scientific phenomena
- To understand the spectral information is mapped using RGB colors
- Hyper spectral (Contains 224 bands of EM range)

Basic relationship b/n Pixels

A pixel will have four neighbours if the neighbours exist in the EAST, WEST, NORTH and SOUTH direction. The four neighbours of the pixel '*P*' pixel are represented in Fig. 1.3.

A pixel '*P*' will have eight neighbours if the neighbours are in eight directions such as EAST, WEST, NORTH, SOUTH, NORTH-EAST (NE), NORTH-WEST (NW), SOUTH-EAST (SE) and SOUTH-WEST (SW). The eight neighbours of the pixel '*P*' are represented in Fig. 1.4.

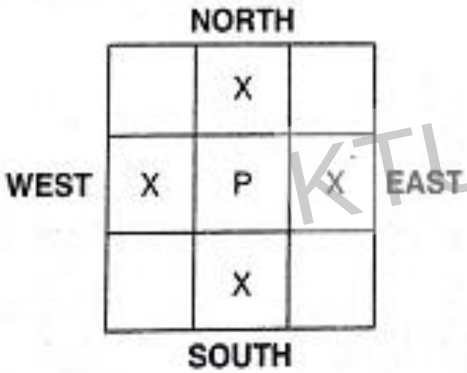


Fig. 1.3 *Four neighbours of the pixel P*

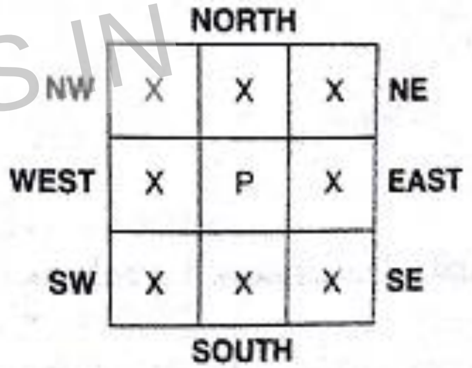
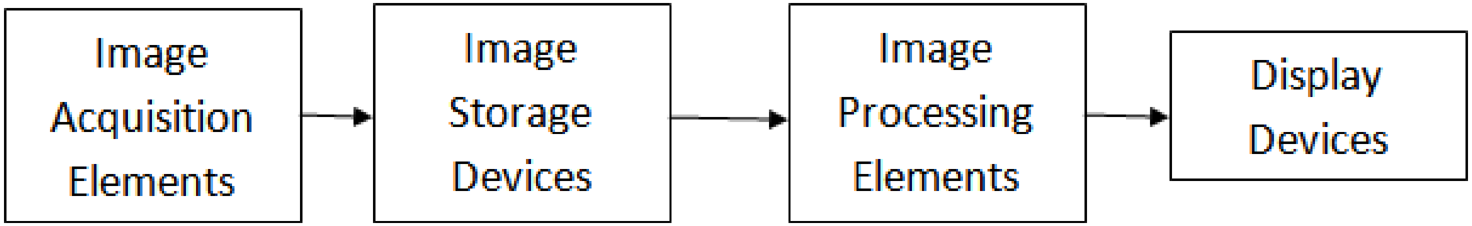


Fig. 1.4 *Eight neighbours of the pixel P*

Elements of DIP System

Block Diagram



1.Image Acquisition Elements

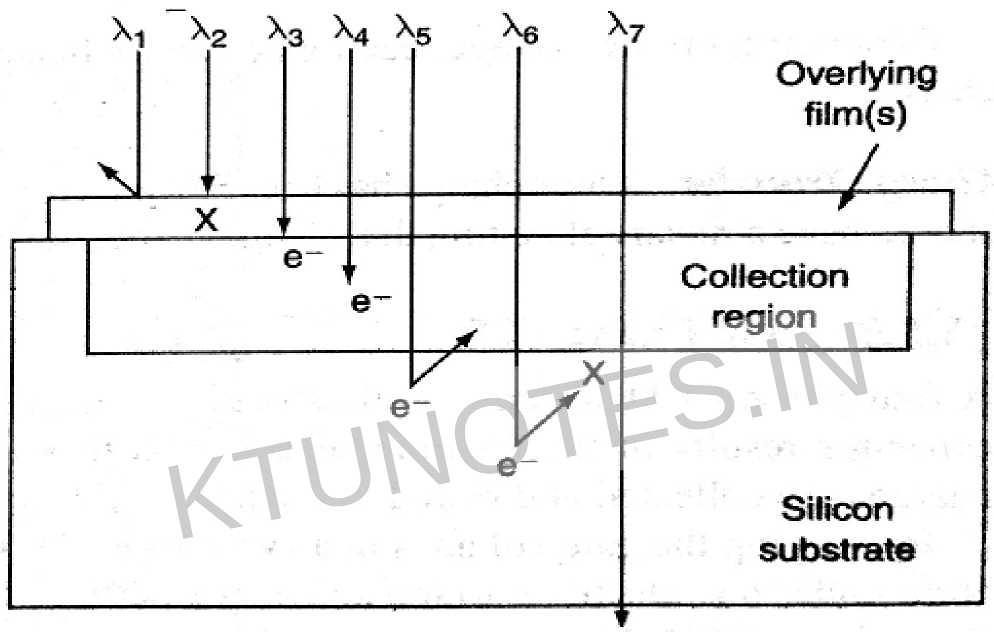
- Two types: CCD Sensor and CMOS Sensor

a) CCD Sensor (Charge Coupled Device Sensor)

- They are arrays of Si-Chips capable of detecting light
- On **exposure** to light , light is converted to charges at discrete sites called pixels
- These packets of charges can be moved inside the Si substrate through a process called **Charge transfer**
- **Charge to Voltage conversion**
- **O/P Amplification**

Elements of DIP System

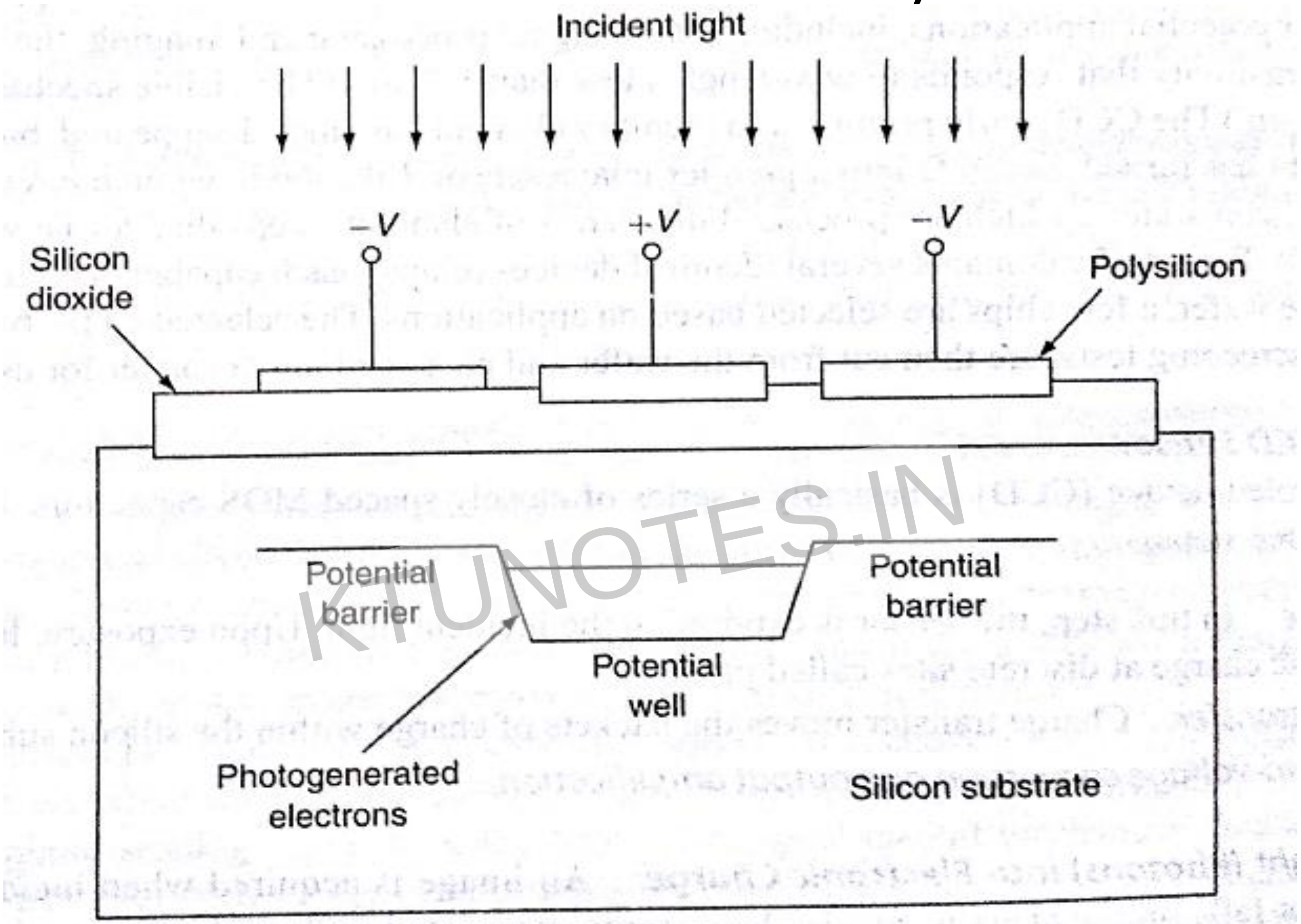
- The formation of charges depends on the wavelength of light



Photon interaction with silicon

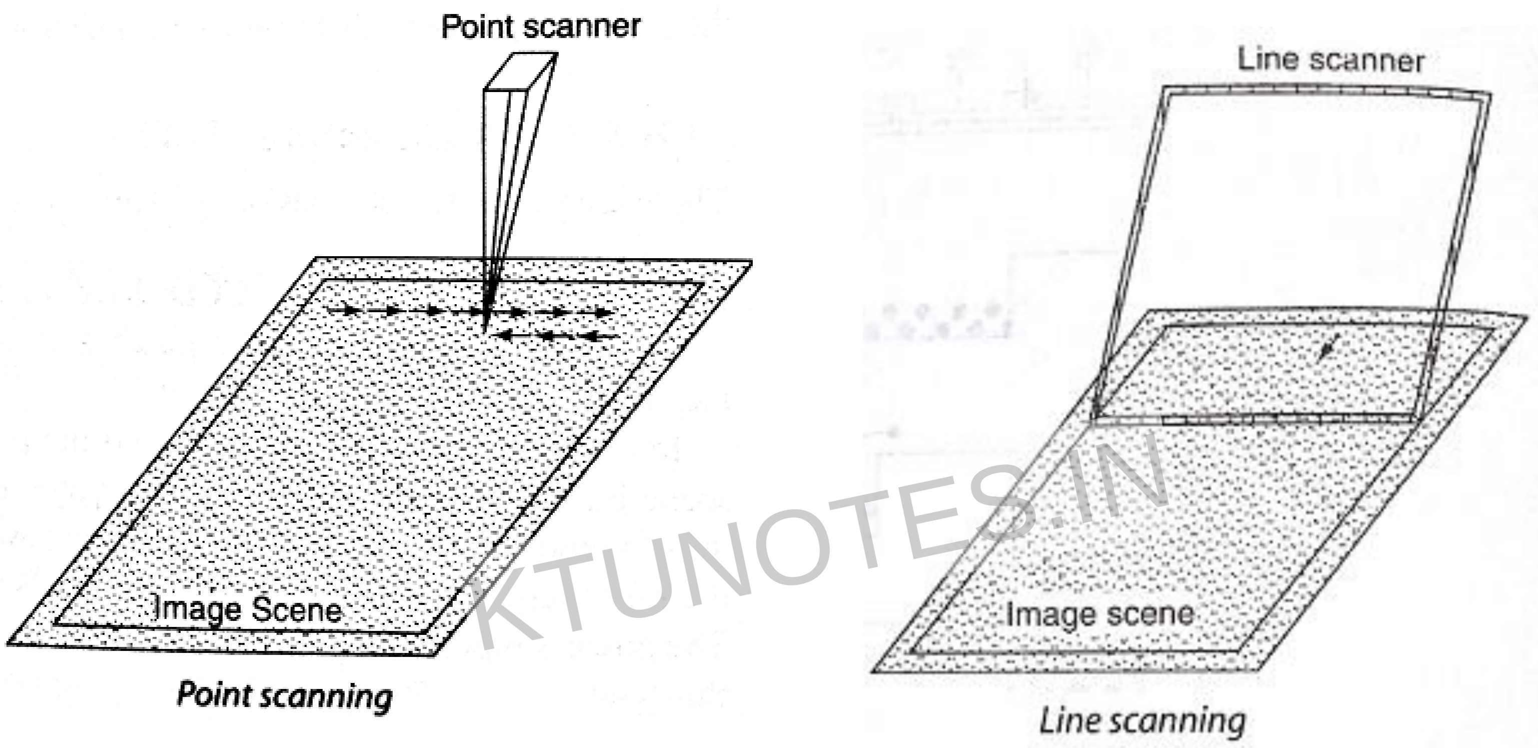
- Charges are captured using MOS technology as **Charge wells** and **Barriers**
- The charges are transferred by varying the **gate voltages** and then send to a **sensor amplifier** as shown:

Elements of DIP System



- Images are sensed using three techniques
- **Point Scanning :** It scans pixel wise as X-Y coordinates

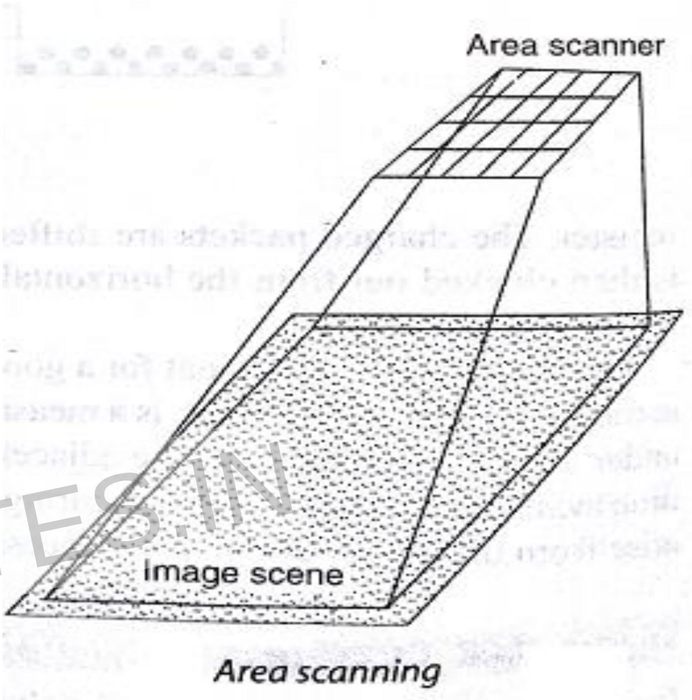
Elements of DIP System



- It is complex and time consuming
- **Line Scanning :** Line information from the scene is captured using array of single cell detectors
- Scanning efficiency is limited by No. of CCD devices
- Scan time Sec~Min

Elements of DIP System

- **Area Scanning :** 2D array of sensors
- Highest frame rate
- Good accuracy
- Less complex
- Limited resolution
- Low SNR
- Higher cost



b) CMOS Image Sensor

<u>Advantages</u>

- Low Power consumption
- Can integrate timing , control and image processing circuitry onto sensor chip
- Random access enables electronic windowing, pan and zoom
- High productivity with low cost

Elements of DIP System

Drawback

- Relatively large FPN (Fixed Pattern Noise)
- Each pixel is amplified separately
- Variations in amplifier gain and offset cause FPN

Comparison of CCD sensor and CMOS image sensor

Feature	*CCD*	*CMOS*
Power consumption	High	Low
Fill factor	High	Low
Dynamic range	High	Moderate
Noise level	Low	High
System complexity	High	Low

Elements of DIP System

2.Image Storage Devices

3 ways to store an image

- Camera to PC
- In built memory of camera
- Camera to removable storage and then to PC

Disk System

- Type I: 3.3 mm thick SRAM
- Type II: NIC, modems etc
- Type III : 10.5 mm thick miniature hard drive

PC storage cards: SRAM (Uses Li-battery) and Flash (can be stored and erased whenever required)

3.Image Processing elements

- It can be a PC or Processor

Which may perform the following functionalities:

Elements of DIP System

- Image transform
- Image Enhancement
- Image restoration and denoising
- Image segmentation
- Object recognition
- Image compression

4.Display Devices

- CRT, LED or LCD Display

Display device selection

- **Size of Monitor:** Smaller gives good portability

TFT (Thin Film Transistor) LCD gives good compactness

- **No of Colors**: No of colors proportional to the ability to handle good resolution images
- **Spatial resolution:** It's the No of pixels (Horizontal X Vertical)

Elements of DIP System

- Common resolution formats

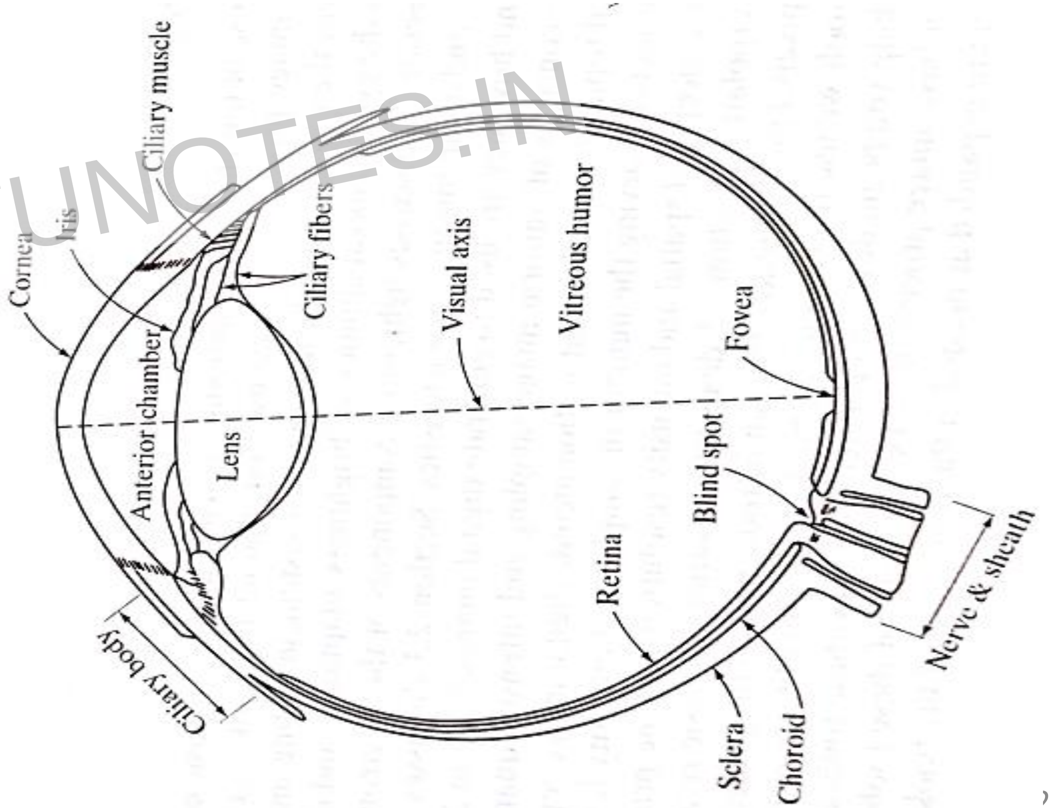
Display mode	*Resolution*
VGA	640 × 480
SVGA	800 × 600
XGA	1024 × 768
SXGA	1280 × 1024
UXGA	1600 × 1200

- VGA-Video Graphics Array
- SVGA-Super VGA
- XGA-Extended Graphics Array
- SXGA-Super XGA
- UXGA-Ultra XGA

Elements of visual perception(simple image formation model)

- This focus on the mechanics and parameters related to how images are formed and perceived by humans
- Comparison of Human visual system and Electronic imaging devices (esp. Resolution and adaptability to illumination)

Structure of Human eye



Elements of visual perception(simple image formation model)

- Spherical structure of 20mm diameter
- 3 layers – Cornea and Sclera (Outer), Choroid (Middle), Retina (Inner)
- Central opening of Iris is called Pupil (2 to 8 mm)
- Ciliary body and Iris holds the lens
- Lens absorbs 8% of visible light spectrum with more absorption at shorter wavelength
- Retina contains Rodes and Cones (6~7 million) concentrated over fovea
- Cone (Photopic-bright light vision)
- Rode (Scotopic-dim light vision)
- Optic nerve starts from Blind Spot (No receptors)
- Line passing through center of lens is called visual axis
- Visual sensitivity decreases 20 deg. off visual axis.
- Human perception is incomparable since it adds intelligence and experience

Elements of visual perception(simple image formation model)

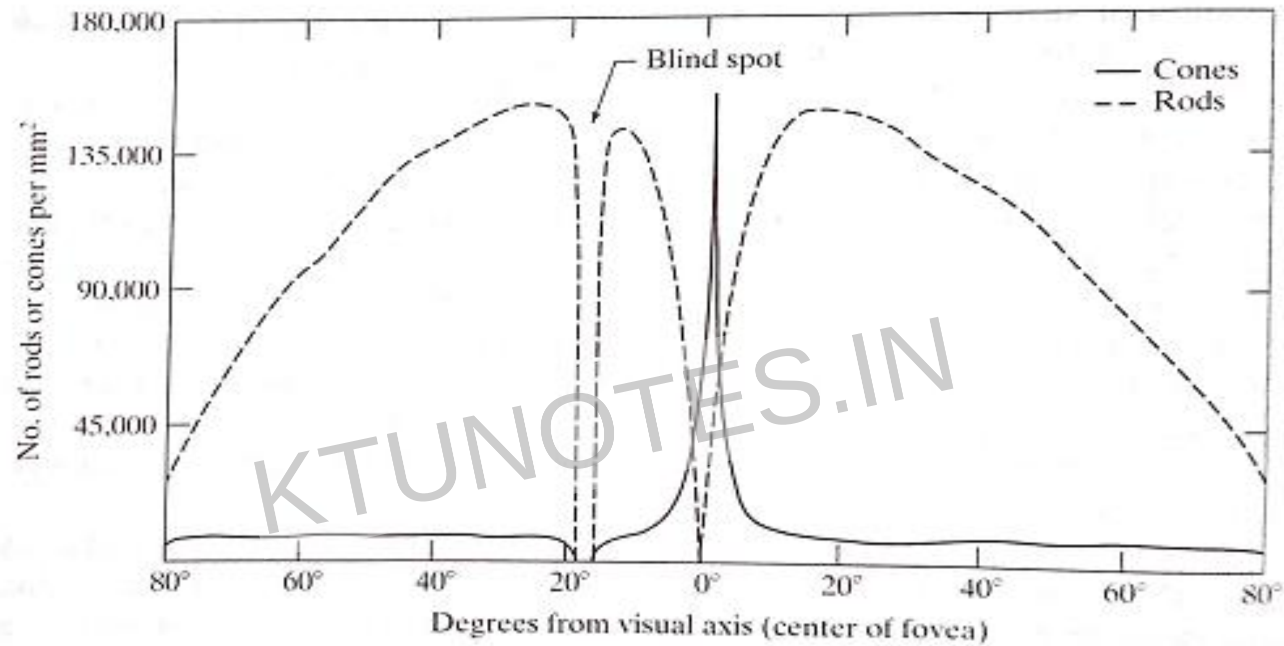
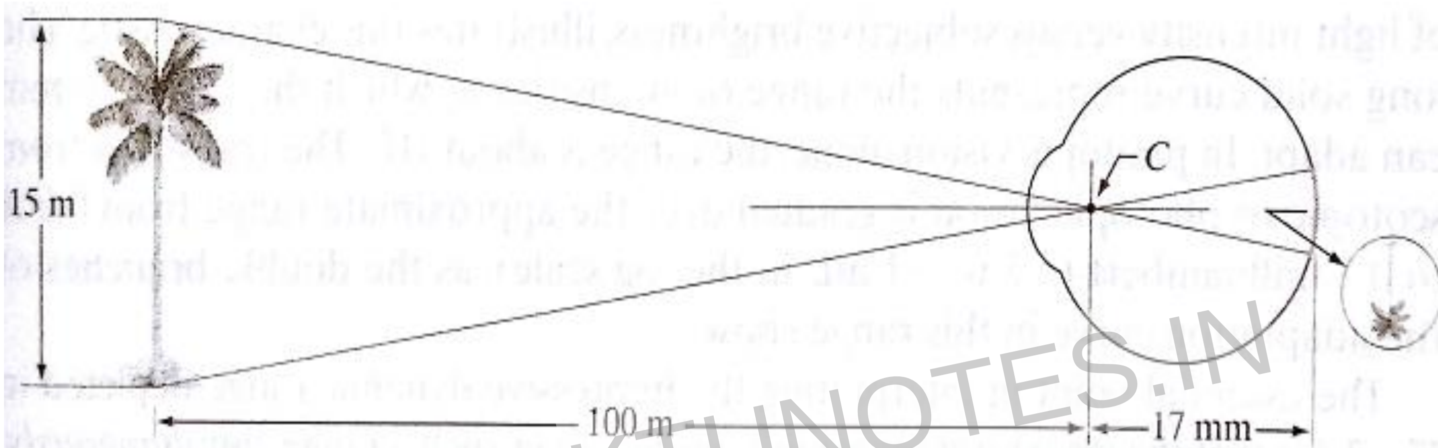


Image Formation in Eye

- Focusing is done by varying the distance between the lens and imaging plane
- Shape of the lens also can vary
- Eye forms a small inverted image on fovea and the receptors transmit the data to visual center of the brain through optic nerve

Elements of visual perception(simple image formation model)



Graphical representation of the eye looking at a palm tree. Point C is the optical center of the lens.

- **Subjective brightness** is a function of Intensity
- The sensitivity of eye (Dynamic range) can vary according to current brightness level and is called- **Brightness adaptation**
- **Weber Ratio:** $\Delta I_c / I$
- ΔI_c = Increment in illumination discriminable 50% of the time
- I = Background illumination

Elements of visual perception(simple image formation model)

Optical Phenomena

Mach band effect

- Is a phenomenon by which human brain subconsciously increases the contrast between two surfaces with different luminance
- The intensity of each bar is uniform but due to Mach band effect darker areas are formed at the boundaries of bands
- And these darker areas are called Mach bands
- It happens due to lateral suppression of receptors and Overshoot /Under shoot of visual systems at intensity variations
- It proves perceived brightness is not a simple function of intensity

Elements of visual perception(simple image formation model)

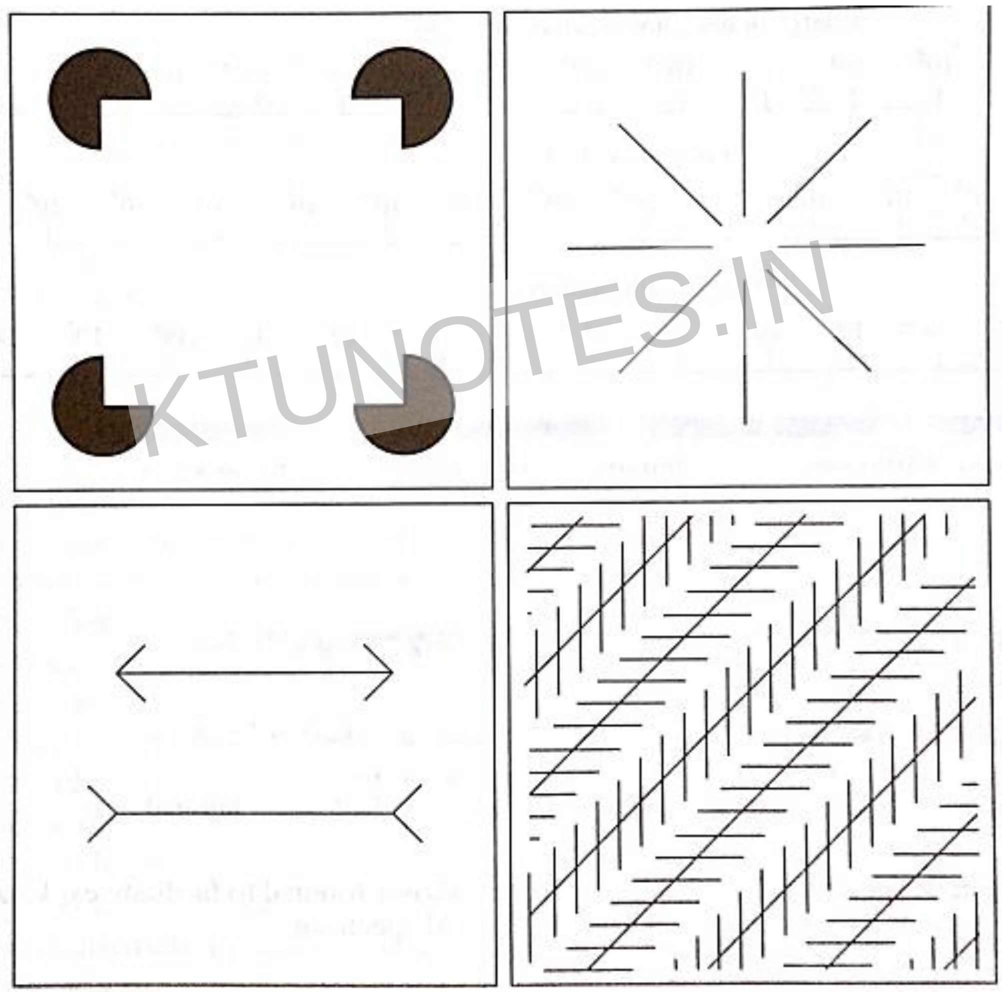
Optical Phenomena

Simultaneous Contrast

- Same intensity will appear different when the background intensity changes
- If the back ground is dark the observed intensity appeared to be lighter
- It proves perceived brightness is not a simple function of intensity

Elements of visual perception(simple image formation model)

Optical Illusions



Elements of visual perception

Simple Image formation model

- Image id denoted as a 2D function ***f(x,y)***
- ***x, y***- Spatial coordinates
- The ***f(x,y)*** at any point is determined by the energy radiated by a physical source
- And is always a positive scalar

$$0 < f(x, y) < \infty$$

The function $f(x, y)$ may be characterized by two components: (1) the amount of source illumination incident on the scene being viewed, and (2) the amount of illumination reflected by the objects in the scene. Appropriately, these are called the *illumination* and *reflectance* components and are denoted by $i(x, y)$ and $r(x, y)$, respectively. The two functions combine as a product to form $f(x, y)$:

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

$$0 < i(x, y) < \infty$$

$$0 < r(x, y) < 1$$

Elements of visual perception

Simple Image formation model

- ***i(x,y)*** is determined by Source
- ***r(x,y)*** is determined by Object

Vidicon Camera

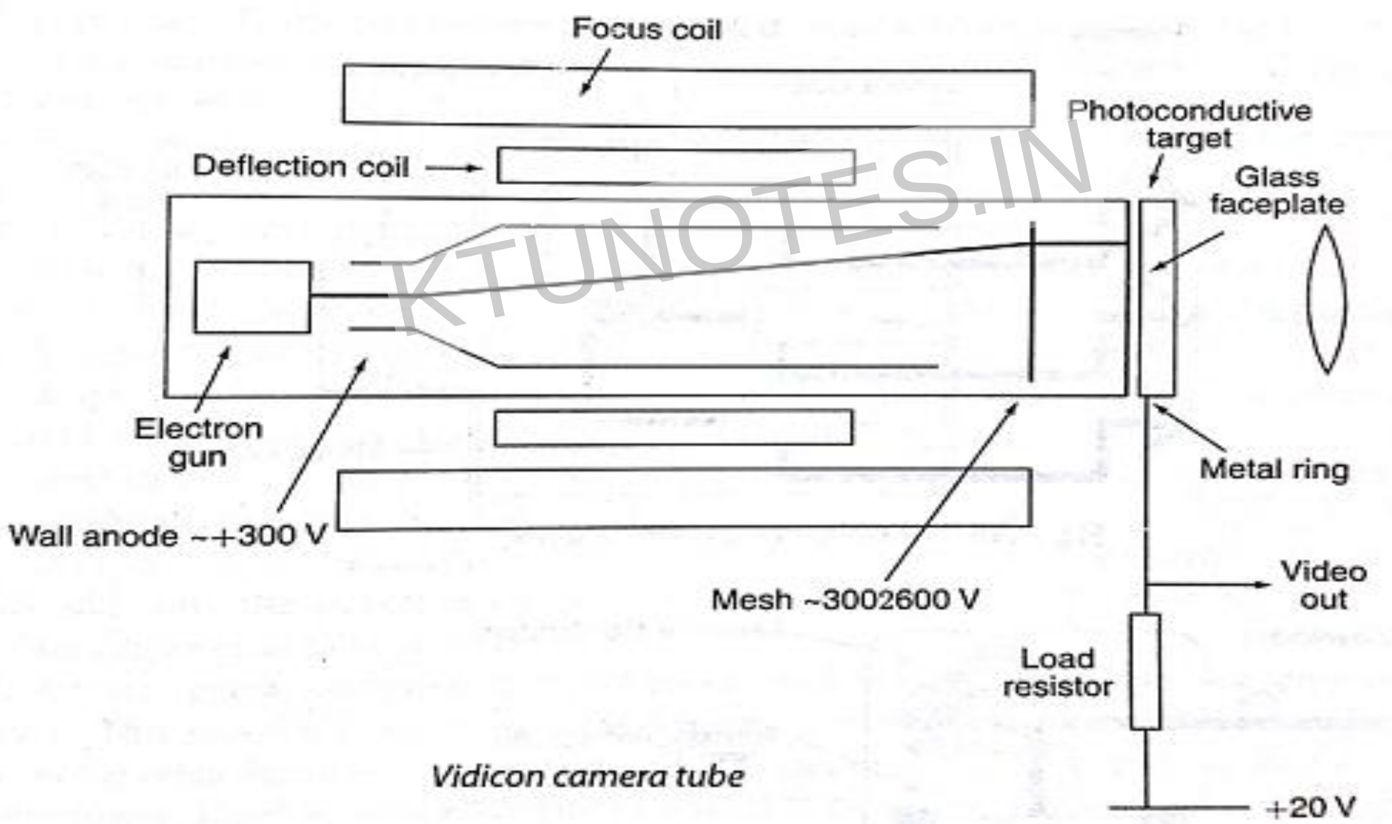
Vidicon-Photo Conductive Camera

- A charge density pattern is formed by the image scene radiation on a photo conductive surface which is then scanned by a beam of low velocity electrons

Vidicon Camera

Vidicon-Photo Conductive Camera

- The fluctuating voltage is coupled out to video amplifier and is used to reproduce the scene
- Photo sensitive material used-**Antimony Tri sulphide**



Vidicon camera tube

Vidicon Camera

Vidicon-Photo Conductive Camera

Working

- The back surface of **target** is scanned by a low velocity electron beam (Acceleration potential of 300~800V)
- This ensures secondary emission ratio < 1
- In darkness target is an insulator and electrons accumulate on it making it negative until its potential become equal to that of **cathode**
- When additional electrons come they trace back their path by *seeing* equal and opposite accelerating field back to the cathode-**Return Beam Vidicon**
- Return beam is noiselessly amplified using a **Photomultiplier** surrounding electron gun
- **Mesh electrode** is used to correct focusing errors at the edges and kept at **slightly above anode potential**
- When target is illuminated it start accumulating positive charges at every gap of electron beam scanning

Vidicon Camera

Vidicon-Photo Conductive Camera

Working

- The charges are stored as capacitances bridged by LDRs
- On the next scan these capacitors can effectively discharge using the incident radiations and the **discharge current contains scene information**

Digital Camera

Working

- It uses image sensors to convert light into charges (**CCD/CMOS**)
- CCD is costly, High resolution, Good sensitivity
- CMOS is Cheap, Low resolution. Low sensitivity, Good battery life
- Typical resolutions:

640 X 480-Low end resolution, Not printable

1216 X 912-Printable

1600 X 1200-High resolution printable on large size

Digital Camera

Working

- High quality camera uses separate color sensors for Primary colors
- The light beam is splitted using **beam splitter**
- Since each pixel location for 3 color information the camera s become bulky and expensive
- Some cameras takes 3 images in rapid succession
- Each pixel contain all 3 color information
- Another more economical and practical way is to checking the neighborhood of pixels to guess the color information of a particular area to use a suitable sensor(**Interpolation**)

Image Parameters

- **Brightness:** It can be defined as the achromatic notion of intensity. But it is not a function of luminance. Give a measure of the amount of radiated or reflected light by a pixel
- **Contrast:** Is the difference between highest and lowest intensity levels in an image
- **Hue:** is associated with the dominant wavelength in a mixture of light waves (Dominant color perceived by observer)
- **Saturation:** Relative purity or the amount of white light mixed with a hue. VIBGYOR is fully saturated (Pure spectrum colors)

Original

Brightness

Contrast

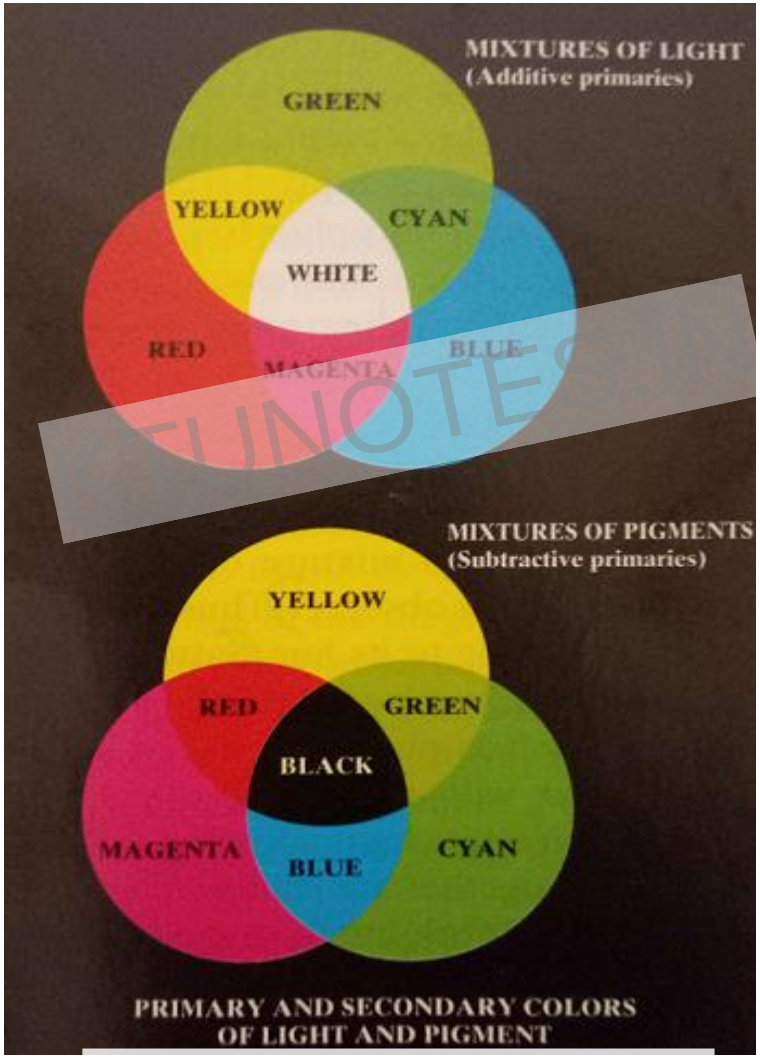
Hue

Saturation

Color Image Fundamentals

Color is the measure of the dominant wavelength reflected out of an object.

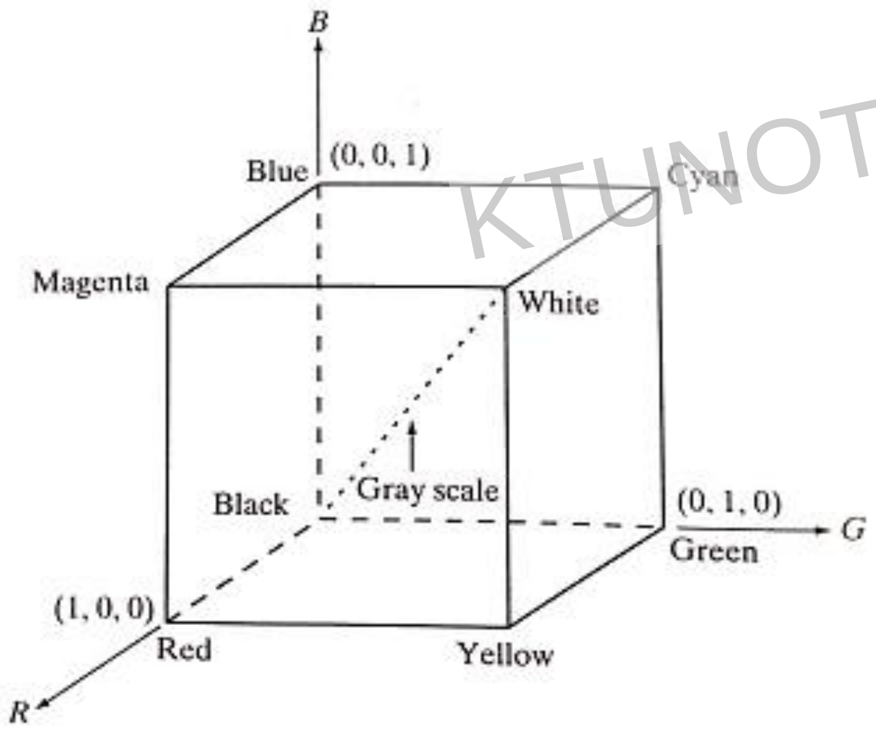
- **Red** (700nm), **Green** (546.1nm), **Blue** (435.8nm)

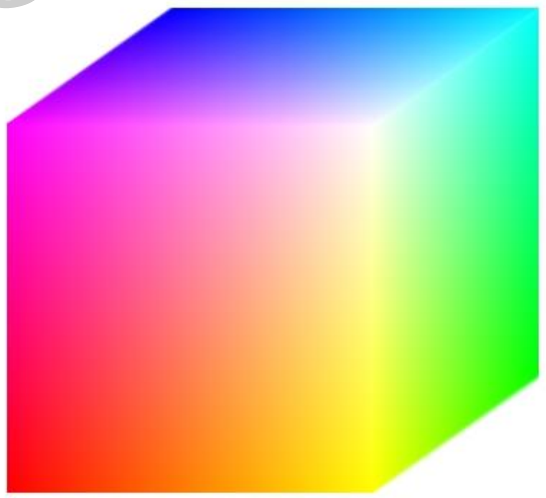


Color Image Fundamentals

1. RGB Model

- Based on primary spectral components
- Cartesian coordinate based system
- RGB color space is shown as a subspace **RGB Cube**
- Origin is **Black** and farthest corner from origin is **White**



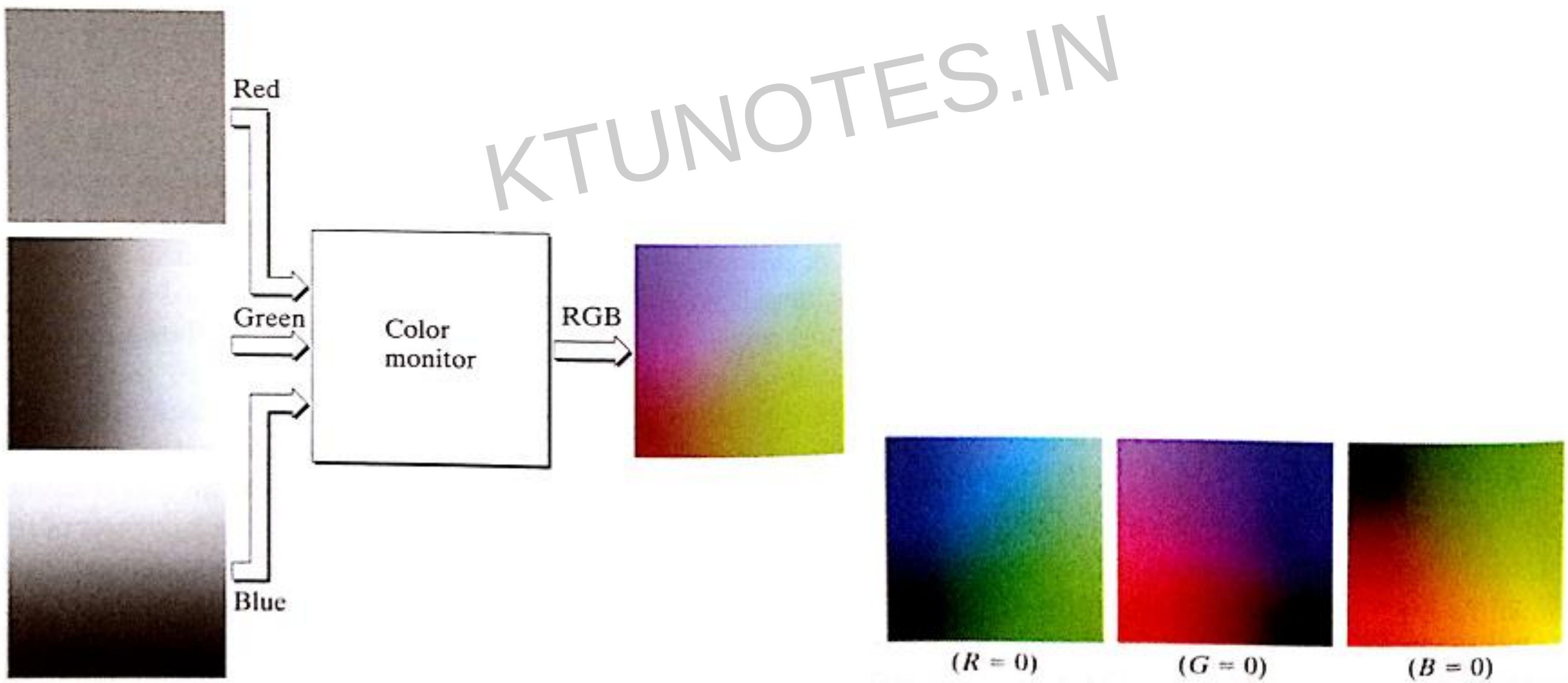


(24 bit cube = 2^24 colors)

Color Image Fundamentals

1. RGB Model

- Most of the system uses 256 colors
- A subset of these can be reproduced faithfully, reasonably independently of viewer hardware capabilities- **System safe colors**(Web colors/Safe browser colors)
- RGB image generation

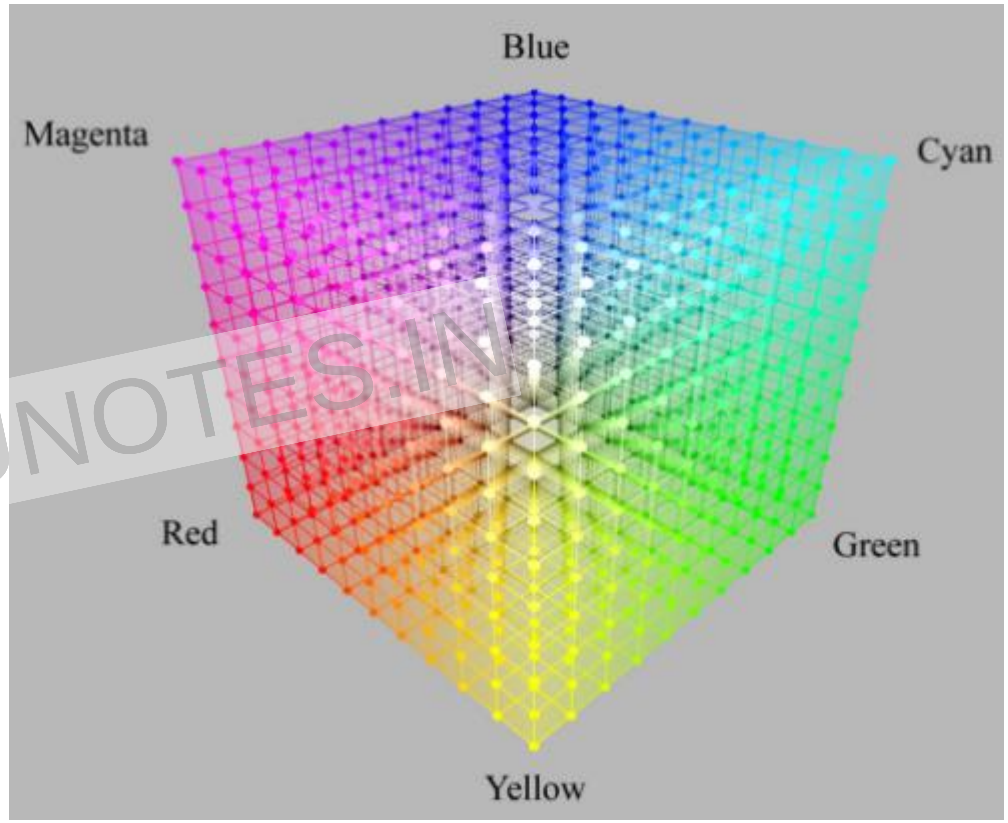


Color Image Fundamentals

2. CMY Model

- **Cyan** (G+B), **Magenta** (R+B), **Yellow**(R+G)

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

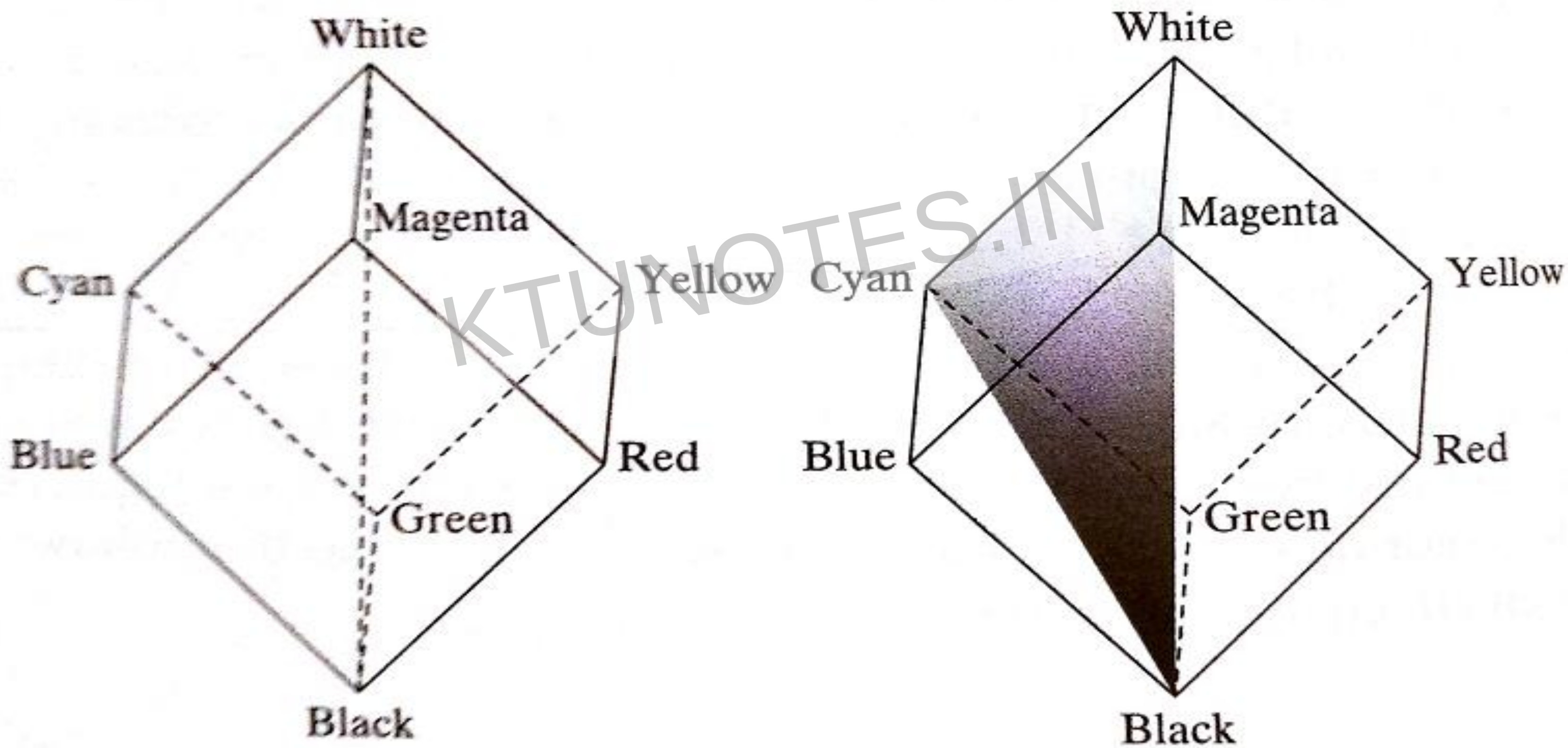


- Pure Cyan absorbs R, Pure Magenta absorbs G, Pure Yellow absorbs B
- C+M+Y in equal amounts produce muddy black-CMYK model

Color Image Fundamentals

3. HSI Model

- **Hue , Saturation, Intensity**
- Useful in developing DIP algorithms that are natural and intuitive to human



Color Image Fundamentals

3. HSI Model

- Take the RGB cube
- By Law: *All colors generated by three colors lie in the triangle defined by those colors*
- So area formed by intensity axis and Cyan will form a triangle which have only one hue (Cyan)
- All the points contained in the plane should have same hue
- If we rotate the plane around intensity axis we can cover all the points with same hue together
- It forms HIS model

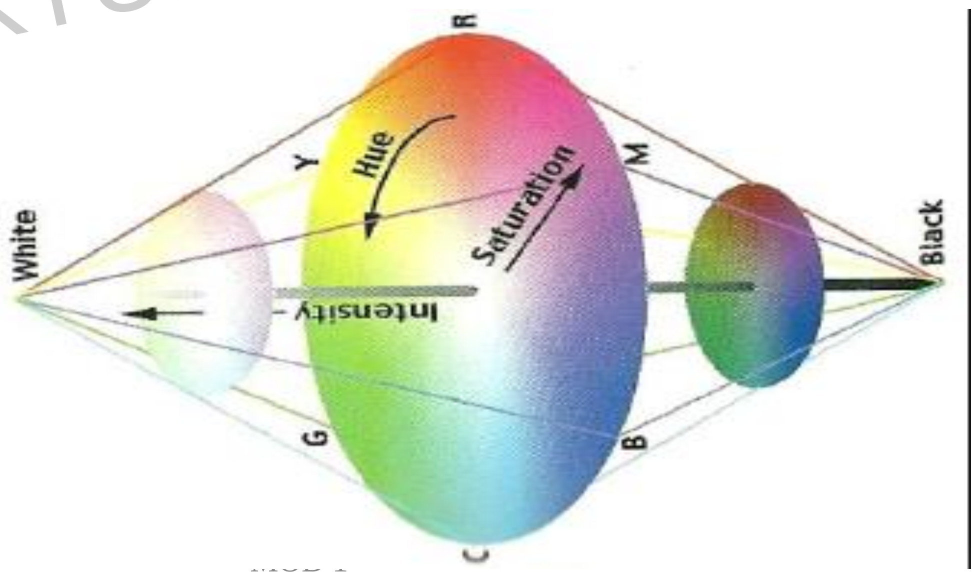


Image Sampling (2D-Sampling)

Image Sampling (2D-sampling)

Consider an analog $f(x, y)$. Let the sampling period along "x-axis" be Δx & that along "y-axis" be Δy. Then the 2D sampled image is given as:

$$f(m, n) = f(m.\Delta x, n.\Delta y) \quad \text{where,}$$

$$m = 0, 1 \ldots M; \quad n = 0, 1 \ldots N$$

The 2D Fourier transform of $f(x,y)$ is given as:

$$F(\Omega_1, \Omega_2) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \left[f(x, y)\, e^{-j\Omega_1 x} \cdot e^{-j\Omega_2 y} \right] dx.dy.$$

Image Sampling (2D-Sampling)

Now the inverse Fourier transform;

$$f(x,y) = \frac{1}{4\pi^2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F(\Omega_1,\Omega_2)\, e^{j\Omega_1 x}\, e^{j\Omega_2 x}\, d\Omega_1\, d\Omega_2$$

when we sample $f(x,y)$;

$$f(m,n) = f(m\Delta x, n\cdot\Delta y)$$

$$f(m,n) = \frac{1}{4\pi^2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F(\Omega_1,\Omega_2)\, e^{j\Omega_1 m\Delta x}\, e^{j\Omega_2 n\Delta y}\, d\Omega_1\, d\Omega_2$$

$\longrightarrow (1)$

Image Sampling (2D-Sampling)

Now we define the discrete frequencies

$$\omega_1 = \Omega_1 \Delta x \longrightarrow (a)$$

$$\omega_2 = \Omega_2 \Delta y \longrightarrow (b)$$

Now, $d\Omega_1 = \frac{d\omega_1}{\Delta x} \longrightarrow (2)$

$$d\Omega_2 = \frac{d\,\Omega_2}{\Delta y} \longrightarrow (3)$$

sub: (2) & (3) in (1)

$$f(m,n) = \frac{1}{4\pi^2} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} F\left(\frac{\omega_1}{\Delta x}, \frac{\omega_2}{\Delta y}\right) e^{j\omega_1 m} e^{j\omega_2 n} \frac{d\omega_1}{\Delta x} \cdot \frac{d\omega_2}{\Delta y}$$

$$f(m,n) = \frac{1}{4\pi^2} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \frac{1}{\Delta x \cdot \Delta y} F\left(\frac{\omega_1}{\Delta x}, \frac{\omega_2}{\Delta y}\right) e^{j\omega_1 m} e^{j\omega_2 n} d\omega_1 d\omega_2 \longrightarrow (4)$$

Image Sampling (2D-Sampling)

To evaluate the double integral we split the 2D image into k_1 squares of area $4\pi^2$ along 'x-axis' & k_2 squares of area $4\pi^2$ along y axis with spacing $\frac{2\pi k_1}{\Delta x}$ & $\frac{2\pi k_2}{\Delta y}$.

eqn (4) becomes:

$$\therefore f(m,n) = \frac{1}{4\pi^2}\int_{-\pi}^{\pi}\int_{-\pi}^{\pi}\frac{1}{\Delta x.\Delta y}\sum_{k_1}\sum_{k_2} F\left(\frac{\omega_1 - 2\pi k_1}{\Delta x}, \frac{\omega_2 - 2\pi k_2}{\Delta y}\right) e^{j\omega_1 m} e^{j\omega_2 n} \, d\omega_1 d\omega_2 \rightarrow (5)$$

Image Sampling (2D-Sampling)

eqn (5) represents the inverse Fourier Transform of $F(\omega_1, \omega_2)$ where :

$$F(\omega_1, \omega_2) = \frac{1}{\Delta x \Delta y} \sum_{k_1} \sum_{k_2} F\left(\frac{\omega_1 - 2\pi k_1}{\Delta x}, \frac{\omega_2 - 2\pi k_2}{\Delta y}\right) \quad \to (5)$$

eqn (5) can be re-written using (a) & (b) as :

$$F(\omega_1, \omega_2) = \frac{1}{(\Delta x \Delta y)} \sum_{k_1} \sum_{k_2} F\left(\Omega_1 - \frac{2\pi k_1}{\Delta x}, \Omega_2 - \frac{2\pi k_2}{\Delta y}\right) \quad \to (6)$$

Image Sampling (2D-Sampling)

The above sampled signal $F(\omega_1, \omega_2)$ in frequency domain can be achieved in another way also:

multiply the image $f(x,y)$ with a 2D - comb function (bed of nail function)

ie $f(m,n) = f(x,y) \times comb(x,y,\Delta x,\Delta y)$ → (7)

where

$$comb(x,y,\Delta x,\Delta y) = \sum_{k_1} \sum_{k_2} \delta(x - k_1\Delta x, y - k_2\Delta y)$$

The Fourier transform of comb function is

$$comb(\Omega_1, \Omega_2) = \frac{1}{\Delta x} \cdot \frac{1}{\Delta y} \sum_{p} \sum_{q} \delta\left(\Omega_1 - \frac{p}{\Delta x}, \Omega_2 - \frac{q}{\Delta y}\right)$$ → (8)

Image Sampling (2D-Sampling)

Taking the Fourier transform of eqn(7)

$$F(\omega_1, \omega_2) = F(\Omega_1, \Omega_2) \otimes comb(\Omega_1, \Omega_2)$$

which gives

$$F(\omega_1, \omega_2) = \frac{1}{\Delta x} \frac{1}{\Delta y} \sum_p \sum_q F\left(\Omega_1 - \frac{p}{\Delta x}, \Omega_2 - \frac{q}{\Delta y}\right) \rightarrow (7)$$

Equations (6) & (7) are comparable.

Image Sampling (2D-Sampling)

Retrieval of Images from samples

In order to retrieve the original image from the sampled spectrum, the following conditions have to be satisfied.

$$\omega_{xs} > 2\omega_{x0} \qquad (1)$$

where $\omega_{xs} = \frac{1}{\Delta x}$ and $2\omega_{x0}$ is the bandwidth of the spectrum in the ω_1 direction.

Similarly,

$$\omega_{ys} > 2\omega_{y0} \qquad (2)$$

where $\omega_{ys} = \frac{1}{\Delta y}$ and $2\omega_{y0}$ is the bandwidth of the spectrum in the ω_2 direction. The condition given in Eqs. **1** and **2** implies that the sampling frequency should be greater than twice the maximum signal frequency, which is generally termed the *sampling theorem*. Here, $2\omega_{x0}$ and $2\omega_{y0}$ are called *Nyquist rates*.

- The discrete image is passed through a LPF

$$H(\omega_1, \omega_2) = \begin{cases} \frac{1}{\omega_{1s}\omega_{2s}}, & (\omega_1, \omega_2) \in \text{region of support} \\ 0 & \text{otherwise} \end{cases}$$

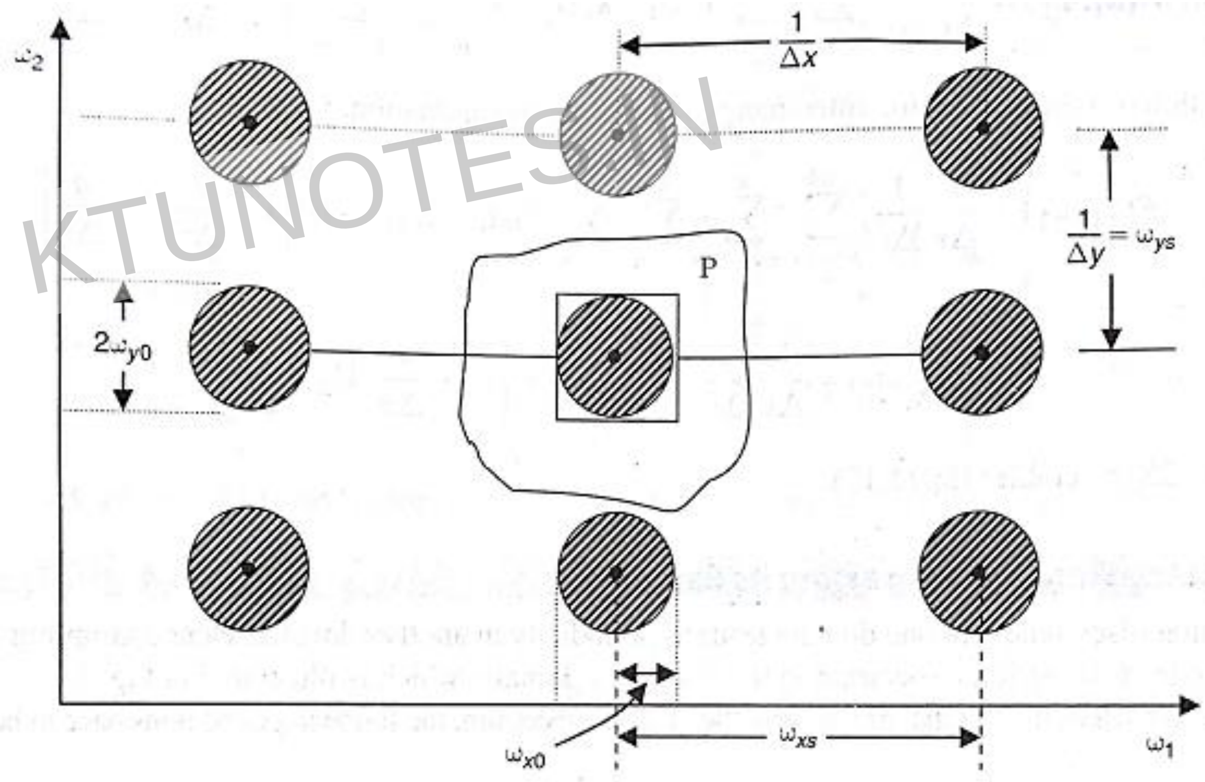
Image Sampling (2D-Sampling)

Retrieval of Images from samples

$$\hat{F}(\omega_1, \omega_2) = H(\omega_1, \omega_2) \times F(\omega_1, \omega_2)$$

- Now applying Inverse Fourier Transform we get back the **reconstructed continuous image**

$$\hat{F}(x, y) = F^{-1}\left\{\hat{F}(\omega_1, \omega_2)\right\}$$

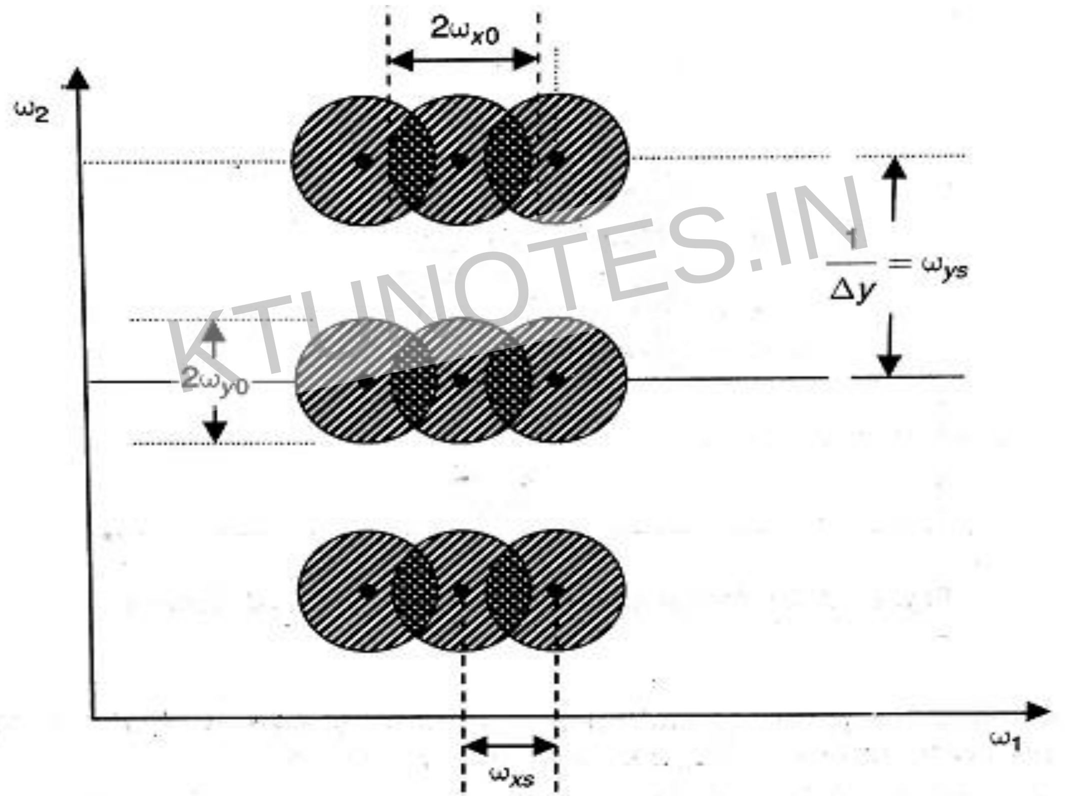


Periodic spectrum of the sampled image

Image Sampling (2D-Sampling)

Image Aliasing

- When, $\omega_{xs} < 2\omega_{x0}$ $\omega_{ys} > 2\omega_{y0}$ Overlapping of pixels occurs in ω_1 direction (X –axis)

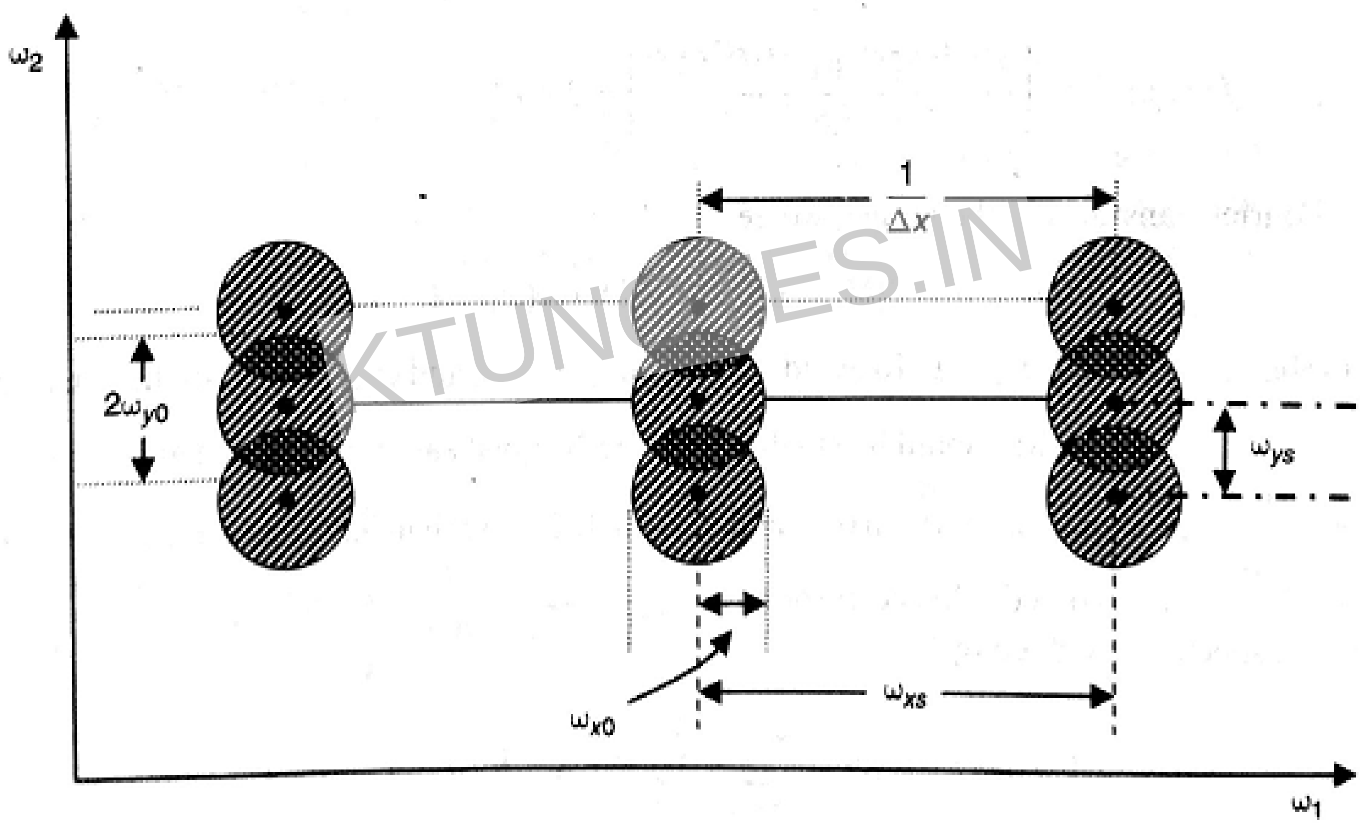


Under-sampling along the ω_1 direction

Image Sampling (2D-Sampling)

Image Aliasing

- When, $\omega_{xs} > 2\omega_{x0}$, $\omega_{ys} < 2\omega_{y0}$ Overlapping of pixels occurs in ω_2 direction (Y –axis)

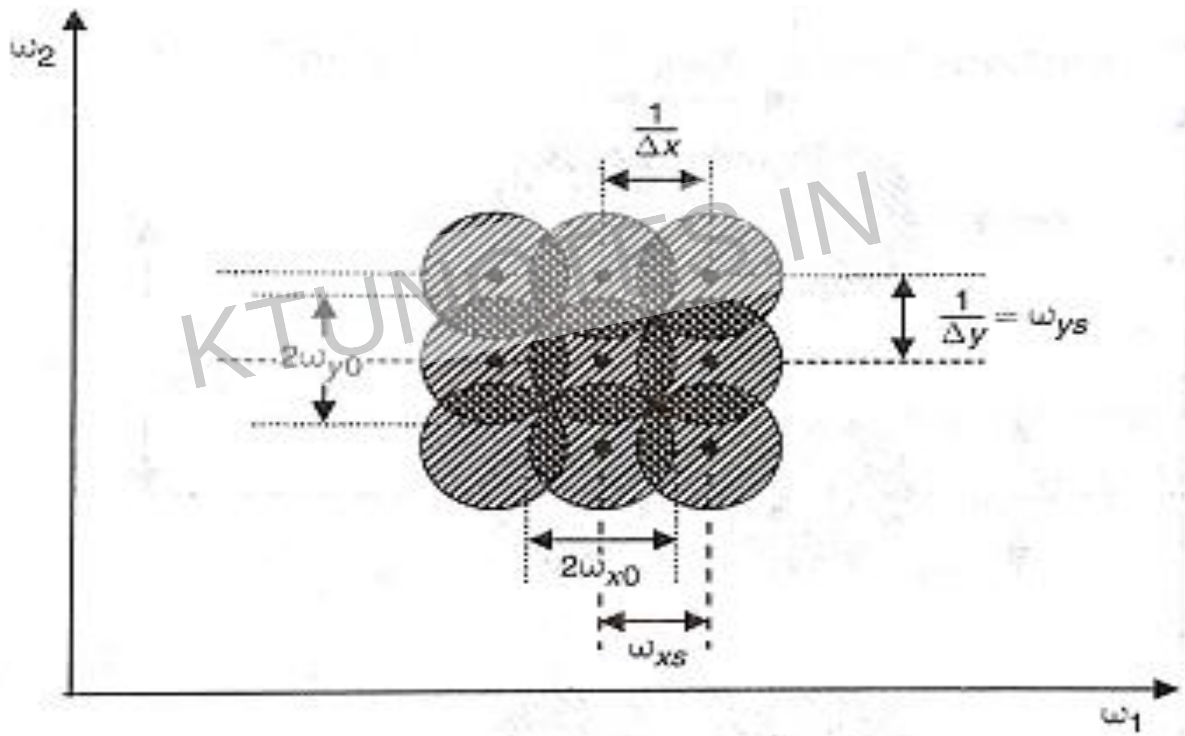


Under-sampling along the ω_2 direction

Image Sampling (2D-Sampling)

Image Aliasing

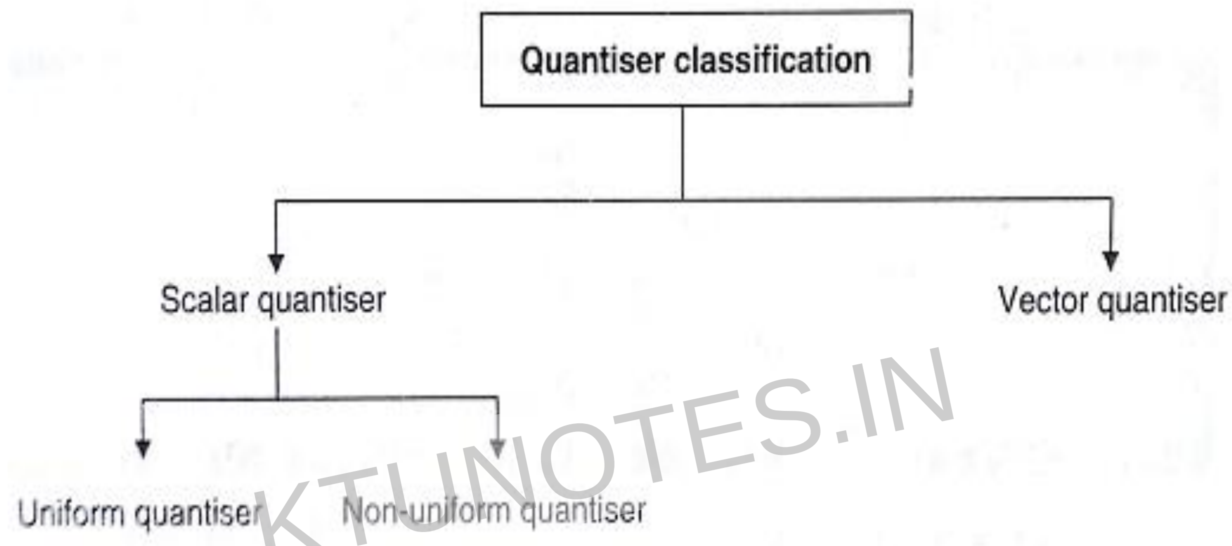
- When, $\omega_{xs} < 2\omega_{x0}$ and $\omega_{ys} < 2\omega_{y0}$. Overlapping of pixels occurs in ω_1 and ω_2 direction (X and Y –axes)



Under-sampling along the ω_1 and ω_2 directions

Image Quantization

Classification



Classification of quantiser

- **Scalar Quantiser**: It is characterized by a ***stair case function*** relating I/P and O/P

a. **Uniform Quantiser**: The step size is uniform except the outer levels

Eg: Midrise, Midtread

Image Quantization

Classification

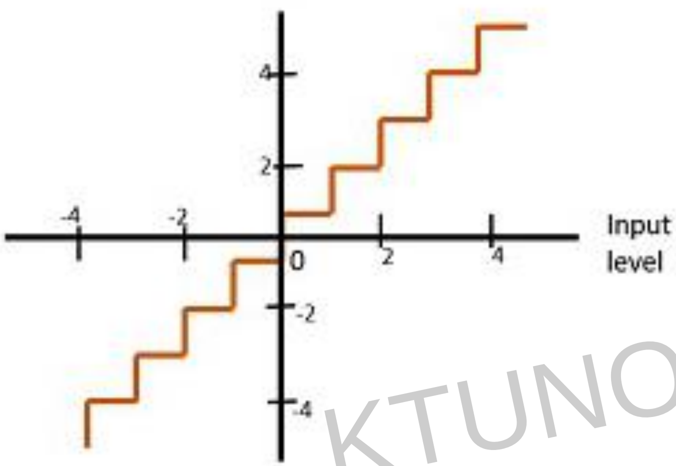


Fig 1 : Mid-Rise type Uniform Quantization

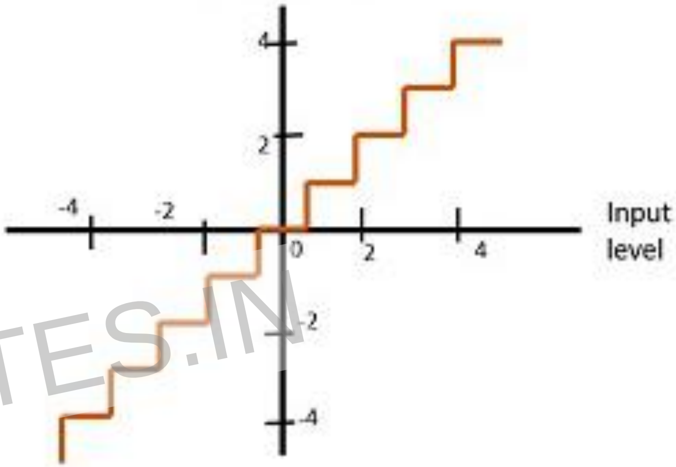


Fig 2 : Mid-Tread type Uniform Quantization

b. Non-Uniform Quantiser: The step size is not uniform

Eg:- Lloyd-Max quantizer

Image Quantization

Classification

Non-Uniform Quantiser

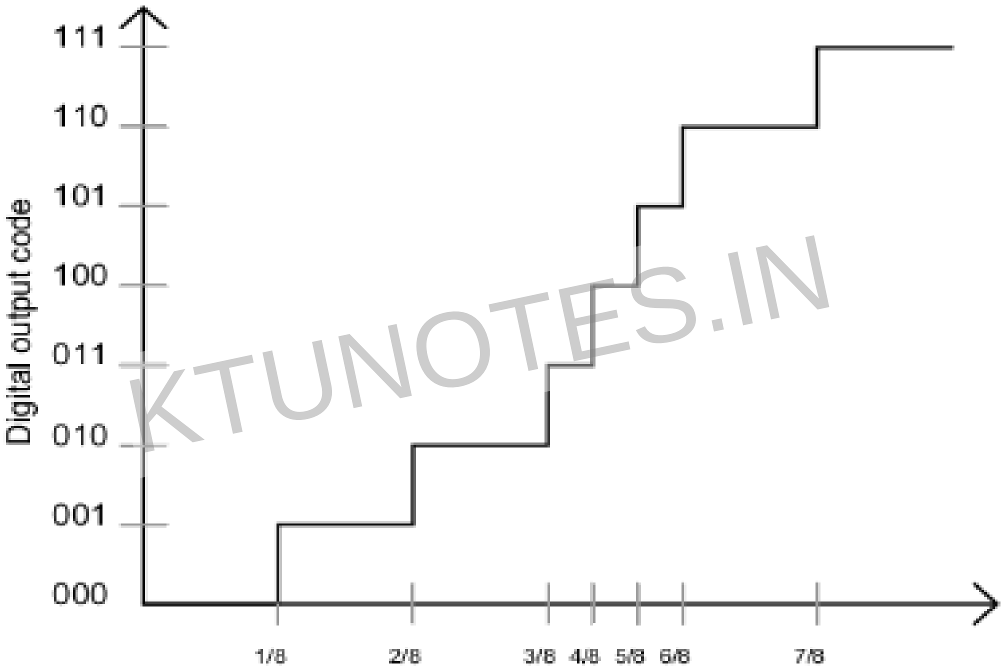


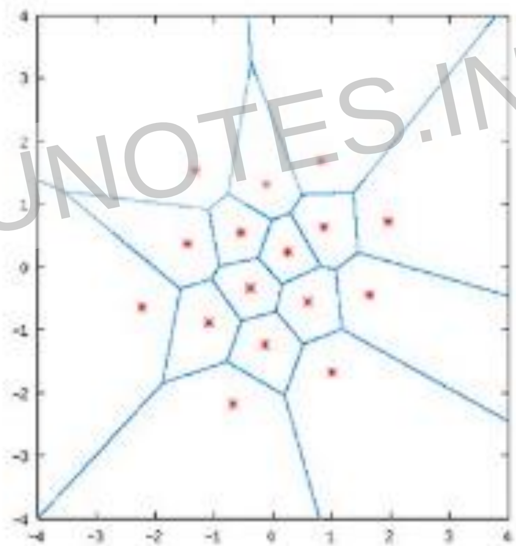
Image Quantization

Classification

- **Vector Quantiser**: It quantizes image block-wise (not Pixel-wise)
- It utilizes ***the correlation*** between pixels to achieve this.

Eg: Tree Search Vector Quantization (TSVQ) , Multi-Stage Vector Quantization (MSVQ)

An example of a 2-dimensional VQ is shown below:



Here, every pair of numbers falling in a particular region are approximated by a red star associated with that region. Note that there are 16 regions and 16 red stars – each of which can be uniquely represented by 4 bits. Thus, this is a 2 dimensional, 4-bit VQ. Its rate is also 2 bits/dimension.


Thank You !!!