# Computer Vision
## Introduction to Digital Imaging

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# What is a Digital Image?

- A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels.
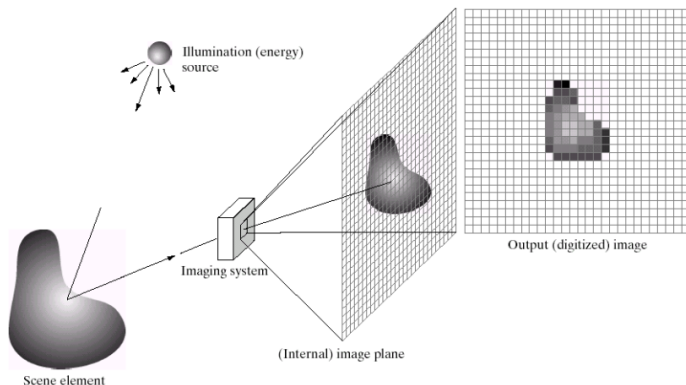


Illumination (energy) source

Scene element

Imaging system

(Internal) image plane

Output (digitized) image

Image source: https://www.researchgate.net/figure/Process-of-Image-Acquisition_fig2_338006863

# What is a Digital Image? (continued...)

- Pixel values typically represent gray levels, colors, heights, opacities, etc.
- Remember digitization implies that a digital image is an approximation of a real scene.
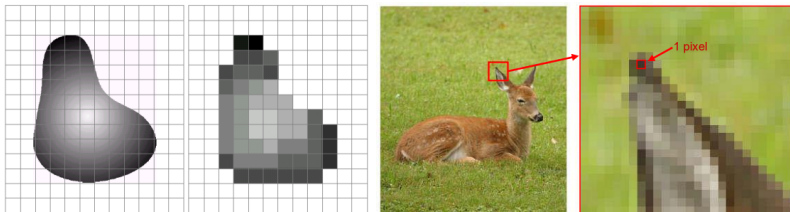
# What is a Digital Image? (continued...)

- Each of the pixels that represents an image stored inside a computer has a pixel value which describes how bright that pixel is, and/or what color it should be.
- In the simplest case of binary images, the pixel value is a 1-bit number indicating either foreground or background.
- For a grayscale images, the pixel value is a single number that represents the brightness of the pixel.
- The most common pixel format is the byte image, where this number is stored as an 8-bit integer giving a range of possible values from 0 to 255.
- Typically zero is taken to be black, and 255 is taken to be white. Values in between make up the different shades of gray.
- To represent color images, separate red, green and blue components must be specified for each pixel (assuming an RGB colorspace).
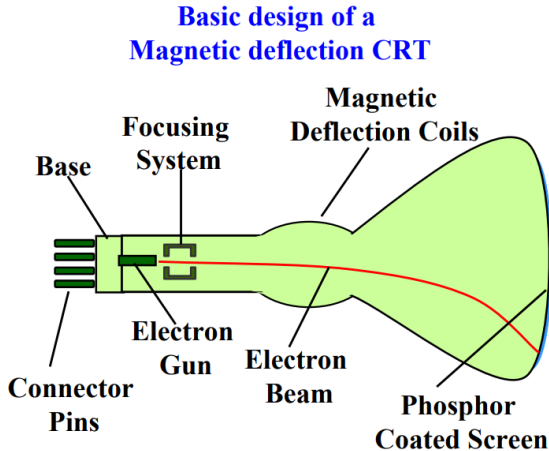
**Operation of an electron gun with an accelerating anode**

Cathode

Focusing Anode

Electron Beam Path

Heating Filament

Control Grid

Accelerating Anode
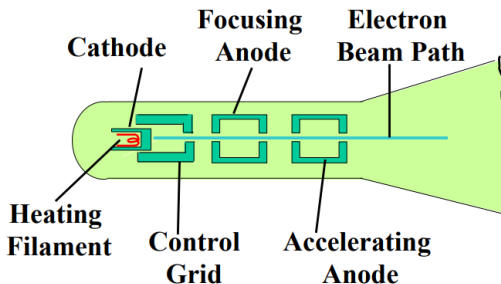
Basic design of a
Magnetic deflection CRT

# Electrostatic deflection of the electron beam in a CRT



Electrostatic deflection of the electron beam in a CRT
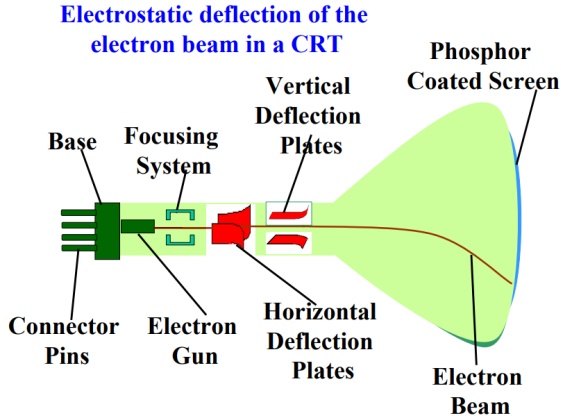
Random-scan display system
draws a set of lines in any order.
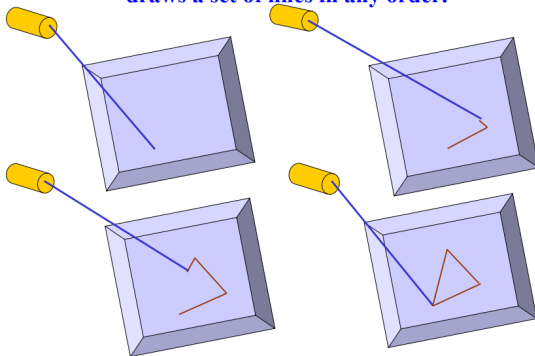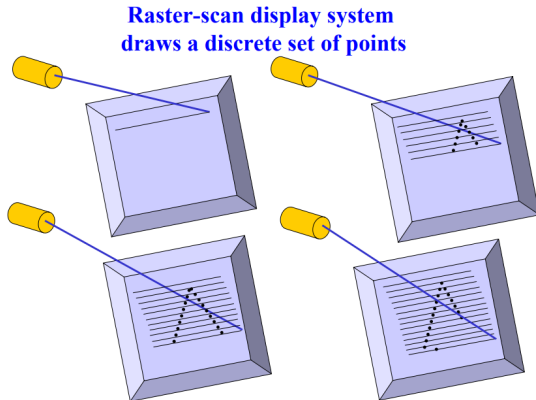
# Ideal line drawing v/s Vector scan
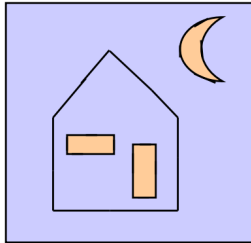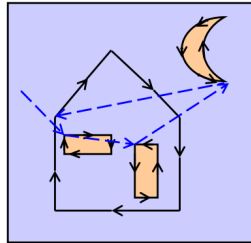


(a) Ideal line drawing      (b) Vector scan

Slide courtesy: Prof. Sukhendu Das IIT Madras

Raster-scan display system
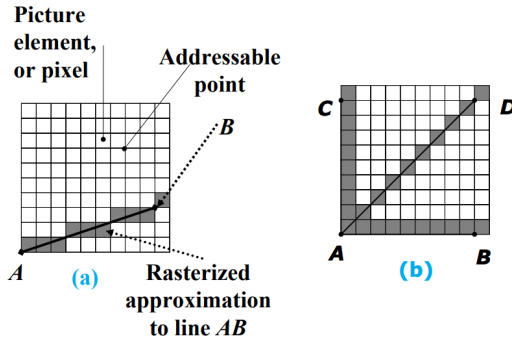draws a discrete set of points

# Rasterization



**Rasterization:** **(a) General line ; (b) special cases**

Picture element, or pixel

Addressable point

B

Rasterized approximation to line *AB*

*A* (a)

*C* *D*

*A* (b) *B*

**Refresh Rate, Video basics and Scan Conversion** (contd.)

A typical example:

If one uses a 512x512 element raster display, then $2^{18}$ bits are necessary in a single bit plane. Memory size required: **32 KB**
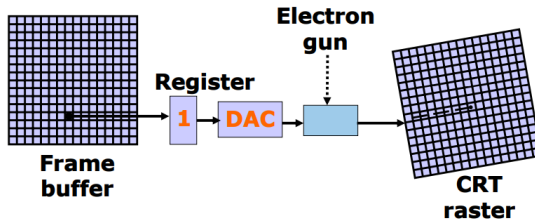
A DAC (digital-to-analog converter) is used to convert the bit value (0, 1) to analog signals for refreshing the screen

Memory size required for N-bit plane gray level frame buffers:

| N | Size in KB |
|----|------------|
| 3 | 96 |
| 8 | 256 |
| 24 | 768 |

Slide courtesy: Prof. Sukhendu Das IIT Madras

# A single bit-plane black & white frame buffer raster CRT graphics device.



**A single** bit-plane **black&white frame buffer raster CRT graphics device.**

Frame buffer → Register **1** → **DAC** → □ → CRT raster

Electron gun

**An N-bit plane gray level frame buffer**

# Simple color frame buffer



Simple color frame buffer

**N-bit plane gray level Frame buffer** (Contd.)

• **In case of one-bit for each color frame buffer, we get 8 colors as:**

| COLOR | RED | GREEN | BLUE |
|-------|-----|-------|------|
| BLACK | 0 | 0 | 0 |
| BLUE | 0 | 0 | 1 |
| GREEN | 0 | 1 | 0 |
| CYAN | 0 | 1 | 1 |
| RED | 1 | 0 | 0 |
| MAGENTA | 1 | 0 | 1 |
| YELLOW | 1 | 1 | 0 |
| WHITE | 1 | 1 | 1 |

Slide courtesy: Prof. Sukhendu Das IIT Madras

**N-bit plane gray level Frame buffer** (Contd.)

• **Typically 8-bit planes per color is used, which gives a 24-bit plane frame buffer**

• **Each group of bit-planes drives an 8-bit DAC**

• **Each group generates 256 shades of intensities of red, green or blue**

• **Hence we obtain $2^{24}$ = 16,777,216 possible colors.**

• **This is called a <u>FULL COLOR FRAME BUFFER</u>**

Slide courtesy: Prof. Sukhendu Das IIT Madras

# A 24-bit-plane color frame buffer



A 24-bit-plane color frame buffer