Computer graphics
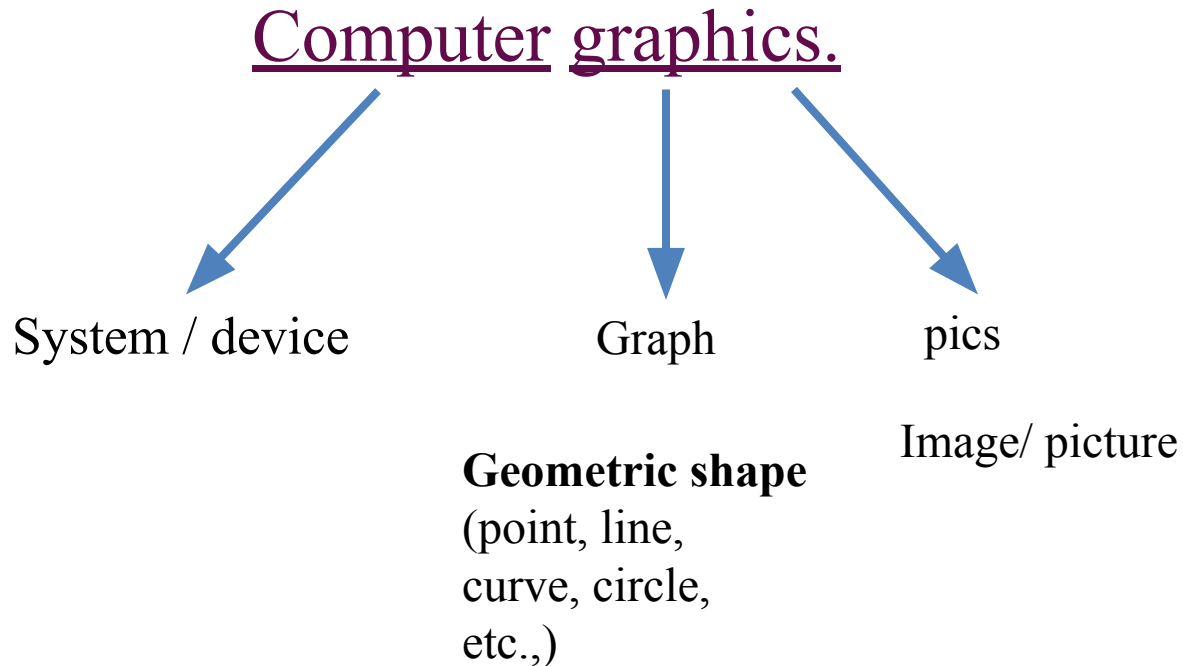
Computer graphics.

The first computer graphics design system was developed by Evan Sutherland as his PhD thesis at MIT in 1963.

Computer graphics.

System / device   Graph   pics

Image/ picture

Geometric shape
(point, line,
curve, circle,
etc.,)

Outline

- **Basic of Computer Graphics**
- **Applications of Computer Graphics**
- **Display Devices**
- **Random and Raster Scan System**
- **Graphics Input Devices**
- **Graphics Software and Standards**

Basic Computer Graphics

- **What is computer graphics?**

- The **computer graphics** is one of the most effective and commonly used way to information in form of graphics object such as pictures, charts, graphs and diagram instead of simple text.

- **Computer graphics** is a process of generating, manipulating, storing and displaying graphics object.
  Ex: Such as pictures, charts, graphs, diagrams.

Basic Computer Graphics

- Thus we can say that computer graphics makes it possible to express data in pictorial form.

- In computer graphics objects are presented as a collection of discrete picture elements.

- **Picture Element = Pixel = Pel**

- The **pixel** is the smallest screen elements.

Basic Computer Graphics

- Graphics should be generated by controlling the pixel.

- The control is achieved by setting the intensity and colour of the pixel which compose screen.

- The process of determining the appropriate pixels for representing picture or graphics object is known as **"rasterization".**

- The process of representing continuous picture or graphics object as a collection of discrete pixels is called **"scan conversion".**

Basic Computer Graphics

- **What you can do with graphics before displaying it on screen?**

✔ Graphics allows rotation, translation, scaling and performing various projections before displaying it.

✔ It also allows to add effects such as hidden surface removal, shading and transparency to the picture.

Basic Computer Graphics

- User can edit (modify content, structure or appearance) graphics object with using keyboard, mouse or touch sensitive panel on the screen.

- There is close relationship between input devices and display devices.

- **Graphics Devices = Input Devices + Display Devices**

Applications of Computer Graphics

- Presentation Graphics
- Entertainment
- Graphics User Interface
- Auto CAD
- Computer Art
- Simulation and Virtual Reality
- Image Processing
- Desktop publication
- Cartography
- Medical application

Presentation Graphics

- In this application reports are generated on slides or transparencies.

- It is normally used to summarize financial, statistical, mathematical, scientific, and economics data for research.

- Graphs and charts can be in 3-D formats to make the presentation.
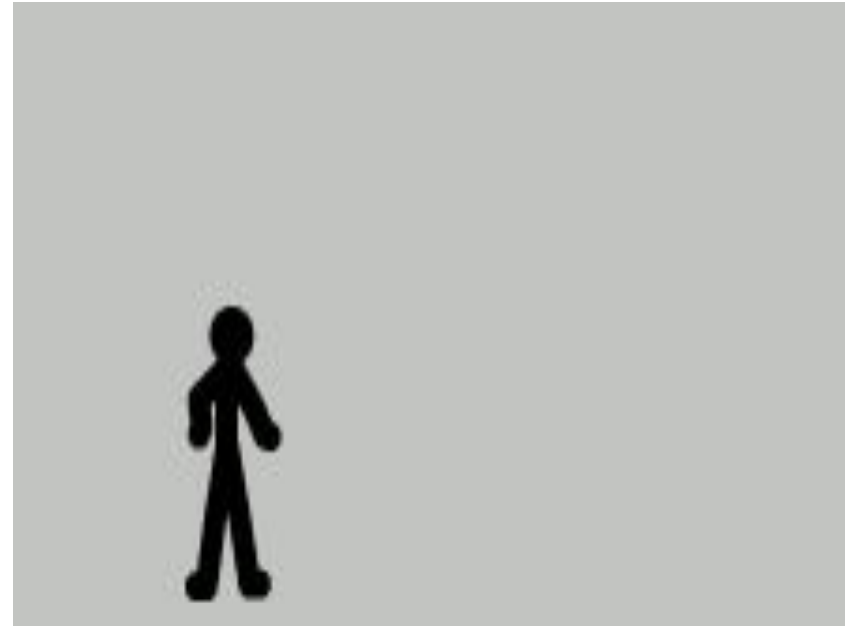
Presentation Graphics

Charts/Graphs
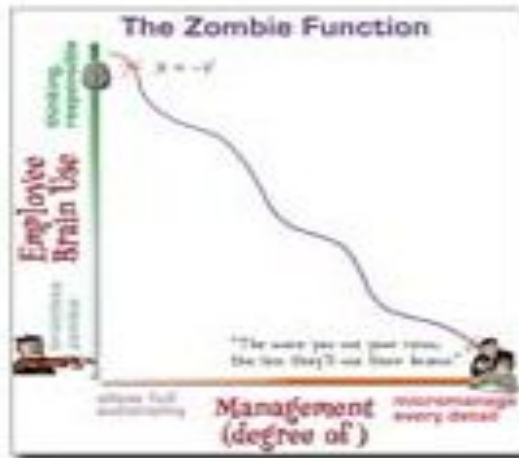
Entertainment

- It is used in making motion pictures, music, videos and television shows.

Entertainment

Graphical User Interface

- Major component of GUI interface is a window manager that allows a user to display multimedia window areas.

- Interface generally comes with a menu and icons for fast selection of processing options.

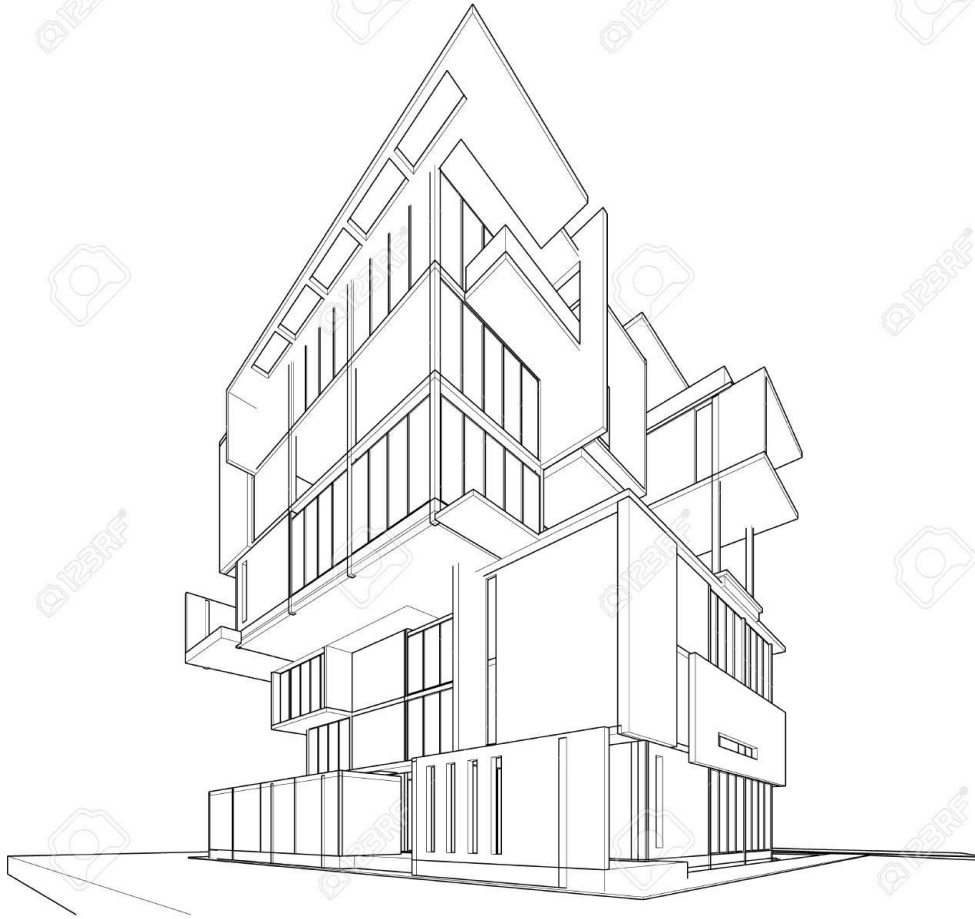- Icon is a graphics symbol designed to look like a processing options.

Graphical User Interface

Auto CAD

- Use of computer graphics is in design process of engineering and architecture system.

- Auto cad applications are design to create building, automobiles, aircraft, spacecraft, textiles and more models.
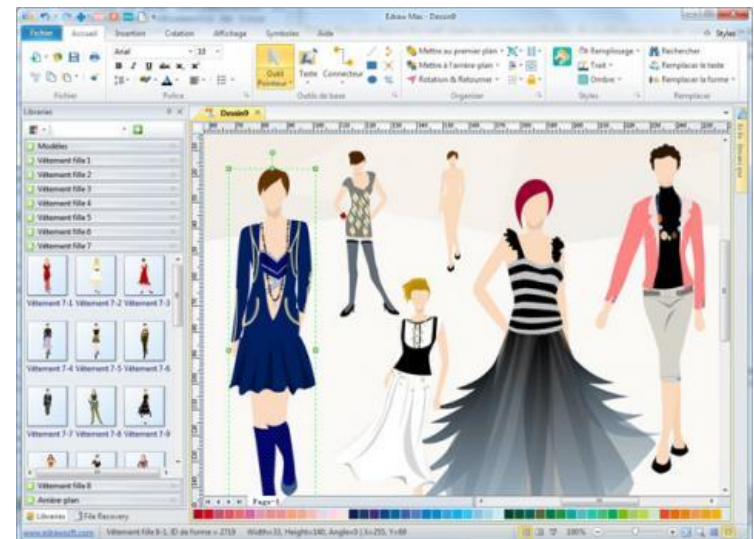
Auto CAD

pixta.jp – 33318897

Computer Art

- Computer graphics widely used in fine arts and commercial applications.

- Artist use a variety of applications like paint packages, mathematics packages, desktop publishing software and animation program.

Computer Art

Virtual Reality

- Virtual reality provides a very realistic effect using sight and sound, while allowing the user to interact with the virtual world.
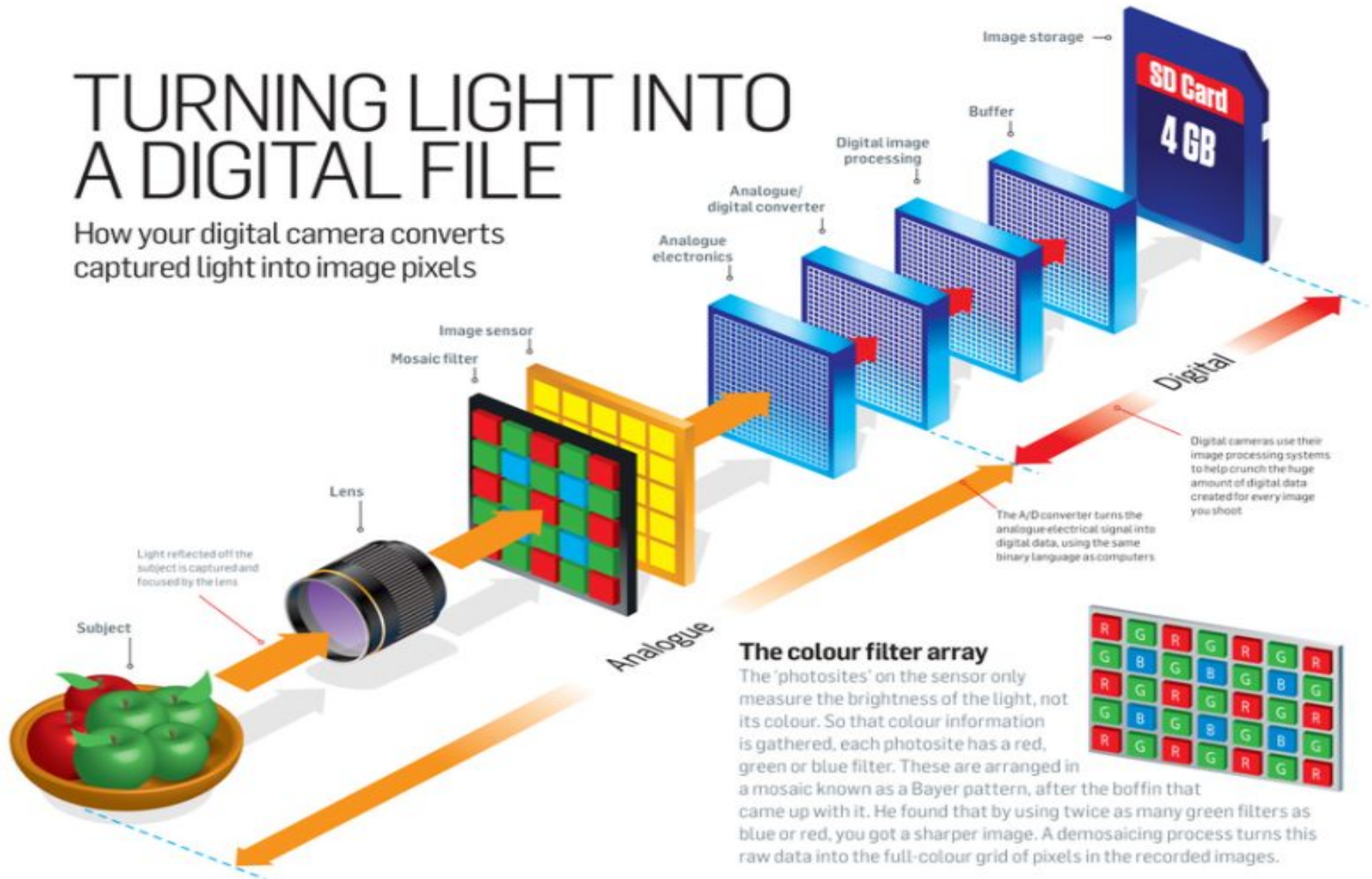
Virtual Reality

Image Processing

- Image processing, converts an existing image into digitized form by converting the image file format.

- Image processing technique is mostly used in commercial application that can rearrange/modify image in different format.
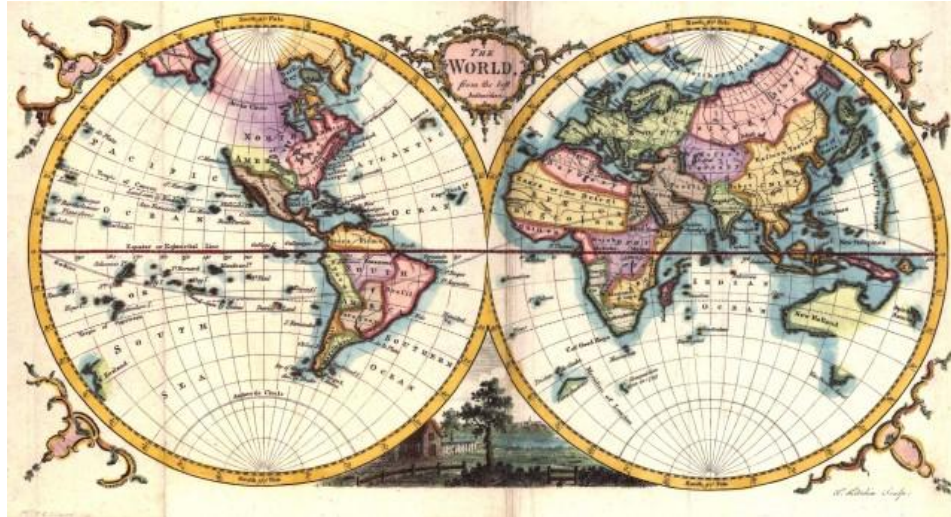
Image Processing

TURNING LIGHT INTO A DIGITAL FILE

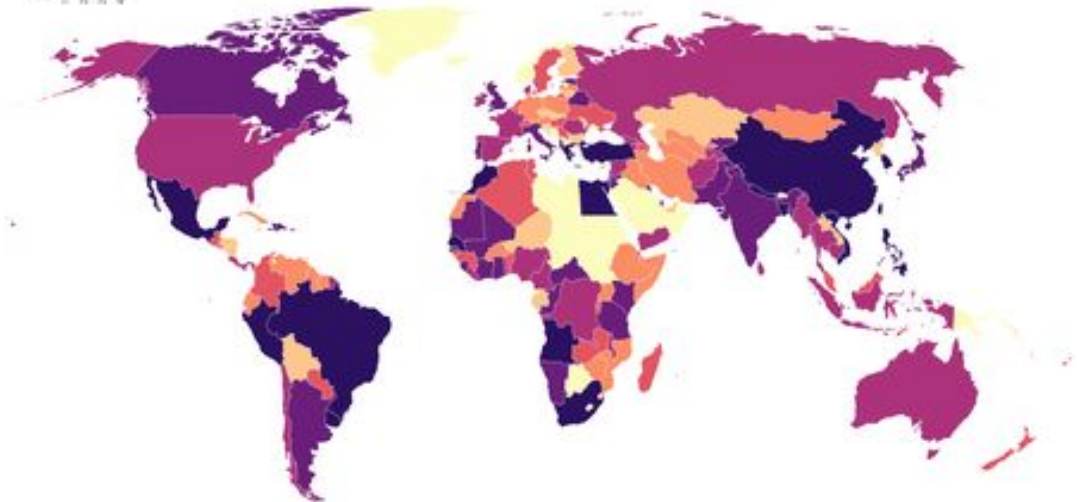How your digital camera converts captured light into image pixels

Image storage

SD Card 4 GB

Buffer

Digital image processing

Analogue/ digital converter

Analogue electronics

Image sensor

Mosaic filter

Lens

Light reflected off the subject is captured and focused by the lens

Subject

Digital

Analogue

Digital cameras use their image processing systems to help crunch the huge amount of digital data created for every image you shoot

The A/D converter turns the analogue electrical signal into digital data, using the same binary language as computers

The colour filter array

The 'photosites' on the sensor only measure the brightness of the light, not its colour. So that colour information is gathered, each photosite has a red, green or blue filter. These are arranged in a mosaic known as a Bayer pattern, after the boffin that came up with it. He found that by using twice as many green filters as blue or red, you got a sharper image. A demosaicing process turns this raw data into the full-colour grid of pixels in the recorded images.

Cartography

Living population density by country
as seen by average country citizen

Population Density [ppl/km2]

# Medical application

pixel

- In digital image, a pixel (picture element) is the smallest item of information in an image. Arranged in 2D grid (row and Column) and are often represented as dots, square, rectangles.

- Pixel is the smallest unit of display on video monitor.

- Intensity of each pixel is variable.

Pixel

red   Green   blue

8 bit
(1 bite)

8 bit
(1 bite)

8 bit
(1 bite)

= 24 bit
= (3 bite) == 1 pixel
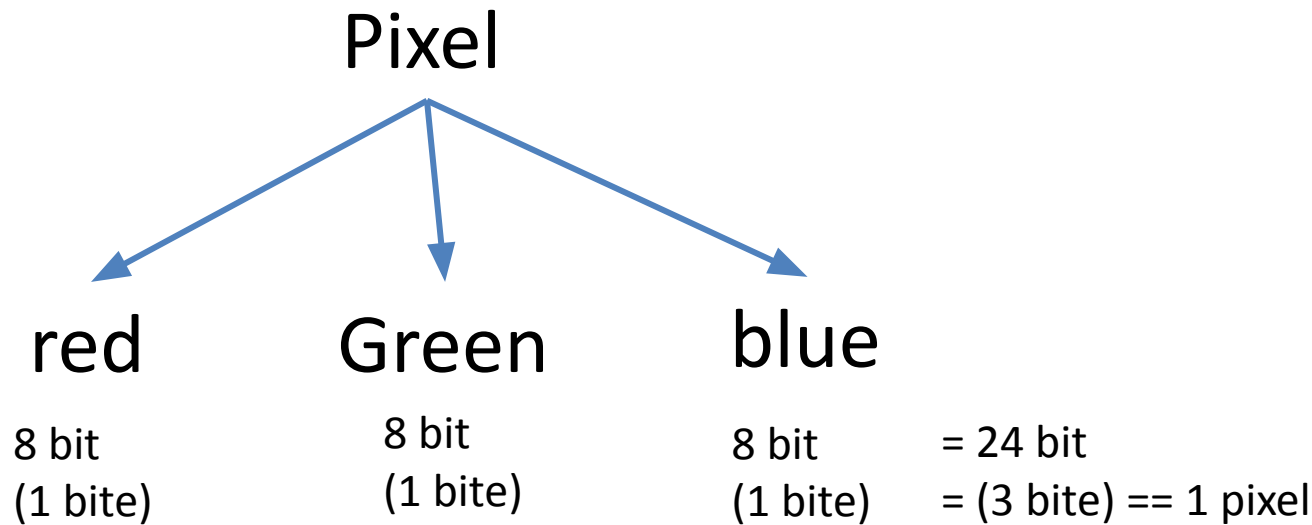
$2^8 = 2*2*2*2*2*2*2*2 = 256$ numerical value (0-255)

$2^8 = 256$ shades of red, green and blue

Total shades 256*256*256 = 16.7 millions shades.

Composite of 3 RGB value create final color for one that pixel area.

Image size = 1000*750 = 750000 pixels

750000*3 =2250000 bytes.

- In RGB === RED + GREEN + BLUE

255	+	255	+	0	== yellow
0	+	0	+	0	== black
255	+	255	+	255	== white
220	+	220	+	220	== light grey
40	+	40	+	40	== dark grey

Display Devices

- Display devices also known as output devices.

- The most commonly used output devices in a graphics system is a video monitor.

Display Devices

- Types of display devices:
  - CRT
  - Radom Scan
  - Raster Scan
  - Colour CRT
  - DVST (Direct view storage)
  - Flat Panel Display
  - Plasma Panel Display
  - LCD

CRT

- **CRT**
  - A CRT is an evacuated glass tube.

  - An **electron gun** at the rear of the tube produces a beam of electron which is directed towards the front of the tube (screen) by a high voltage.

  - The inner side of the screen is coated with phosphor substance which gives off light when it is stroked by electron.

  - The **control grid** voltage determines the velocity achieved by the electrons before they hit the phosphor.
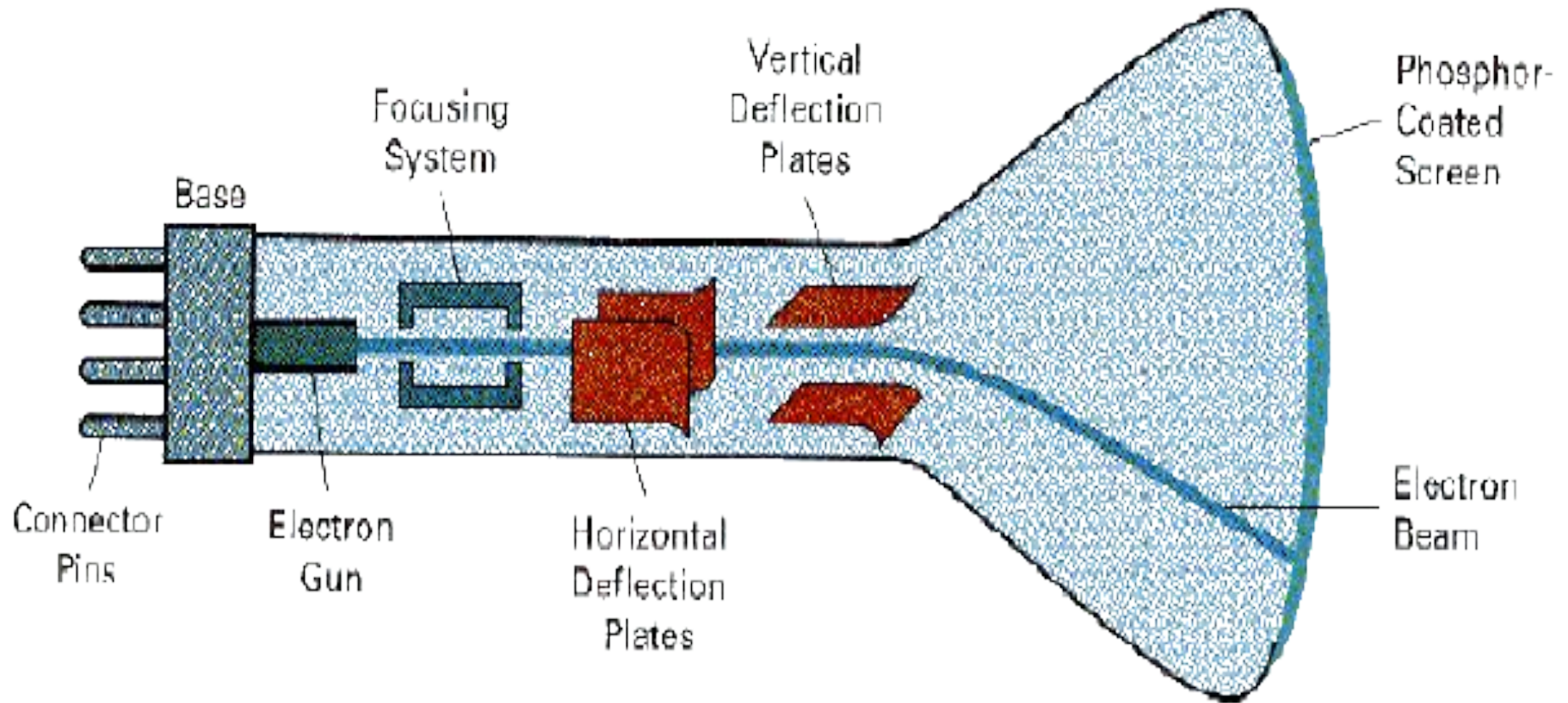
Cathode Ray Tube

CRT

- **CRT**
  - The control grid voltage determines how many electrons are actually in the electron beam.

  - Thus, control grid controls the intensity of spot where the electron beam is strike the screen.

  - **The focusing system** concentrates the electron beam so that the beam converges to a small point when it hits the phosphor coating.

CRT

- **CRT**
  - The deflection system of the CRT consists of two pairs of parallel plates, referred to as the **vertical** and **horizontal deflection plates.**

  - The voltage applied to vertical deflection of the electron beam and voltage applied to the horizontal deflection plates controls the horizontal deflection of the electron beam.

  - There are two techniques used for producing images on the CRT screen : **Random Scan (Vector scan)** and **Raster Scan.**

Colour CRT

- **Colour CRT**
  - A CRT monitors displays colour pictures by using a combination of phosphors that emit different-coloured light. It generates a range of colours by combining the emitted light from different phosphors.

  - There are two basic techniques used for producing colour displays:
    - **Bean-Penetration technique**
    - **Shadow mask technique**

Colour CRT

- **Beam-penetration technique:**
  - This technique is used with random-scan monitors.

  - In this technique, the inside of CRT screen is coated with two layers of phosphor, usually red and green.

  - The displayed colour depends on how far the electron beam penetrates into the phosphor layers.

  - The outer layer is of red phosphor and inner layer is of green phosphor.

Colour CRT

- **Beam-penetration technique:**
  - A beam of slow electrons excites only the outer red layer.

  - A beam of very fast electrons penetrates through the red layer and excites the inner green layer.

  - At intermediate beam speeds, combination of red and green light are emitted and two additional colours, orange and yellow displayed.

  - The beam acceleration voltage controls the speed of the electrons and hence the screen colour at any point on the screen.
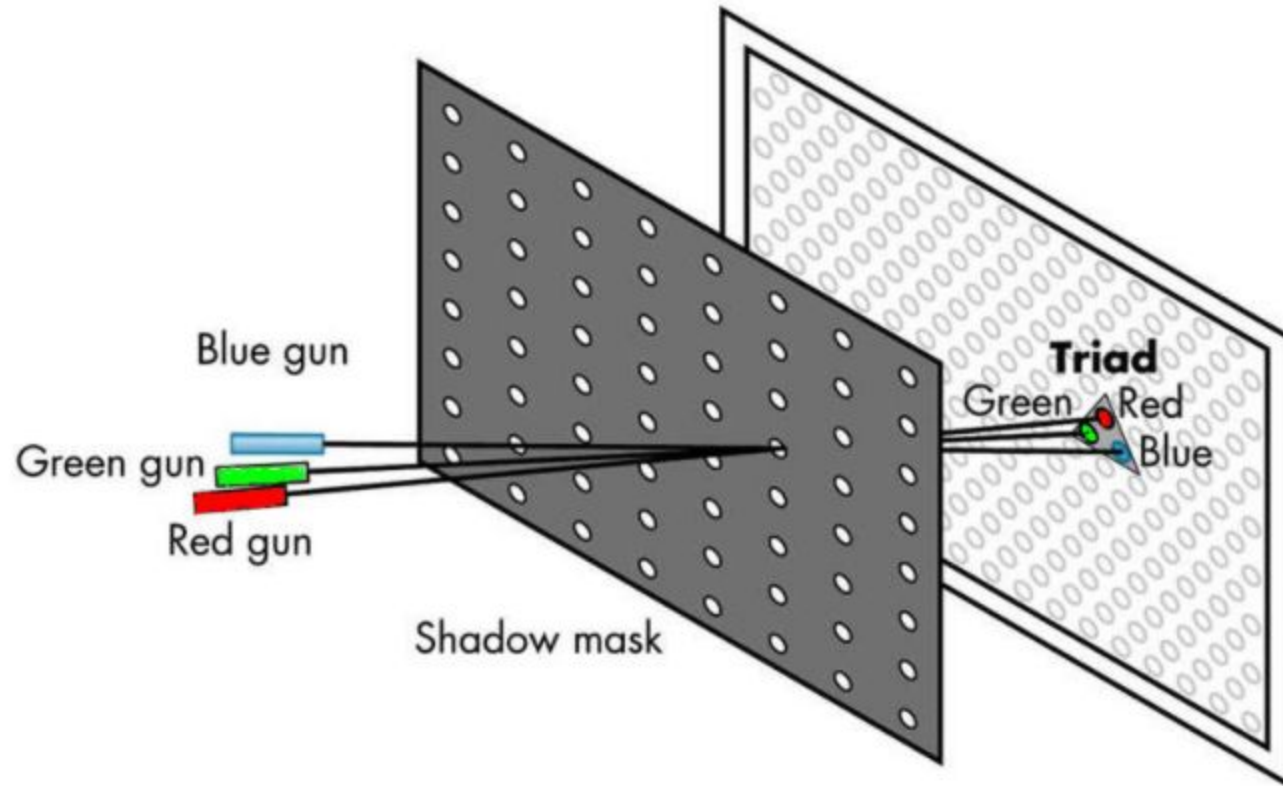
Colour CRT

- **Beam-penetration technique:**

  - Merits:
    - It is inexpensive technique to produce colour in random scan monitors.

  - Demerits:
    - It can display only four colours
    - The quality of picture produced by this technique is not good as compared to other techniques.

Colour CRT

- **Shadow Mask Technique:**
  - The shadow mask technique produces a much wider range of colours then the beam penetration technique.

  - Hence this technique is commonly used in raster-scan displays including colour TV.

  - In a shadow mask technique, CRT has three phosphor colour dots at each pixel position.

  - One phosphor dots emits a red light, another emits green light and third emits green light.

Colour CRT

Shadow mask techniques

Colour CRT

- **Shadow Mask Technique:**
  - It has three electron guns, one for each colour dot, and a shadow mask grid just behind the phosphor coated screen.

  - The shadow mask grid consists of series of holes aligned with the phosphor dot pattern.

  - Three electron beams are deflected and focused as a group on to the shadow mask and when they pass through a hole in the shadow mask, they excite a dot triangle.

Colour CRT

- **Shadow Mask Technique:**
  - A dot triangle consists of three small phosphor dots of red, green and blue colour.

  - A dot triangle when activated appears as a small dot on the screen which has colour of combination of three small dot on the screen which has colour of combination of three small dots in the dot triangle.

  - By varying the intensity of the three electron beams we can obtain different colours in the shadow mask CRT.

DVST

- **DVST:**
  - DVST stands for direct view storage tube.

  - In raster scan display we do refreshing of the screen to maintain a screen image.

  - The DVST give alternate method of maintaining the screen image.

  - A DVST uses the storage grid which stores the picture information.

DVST
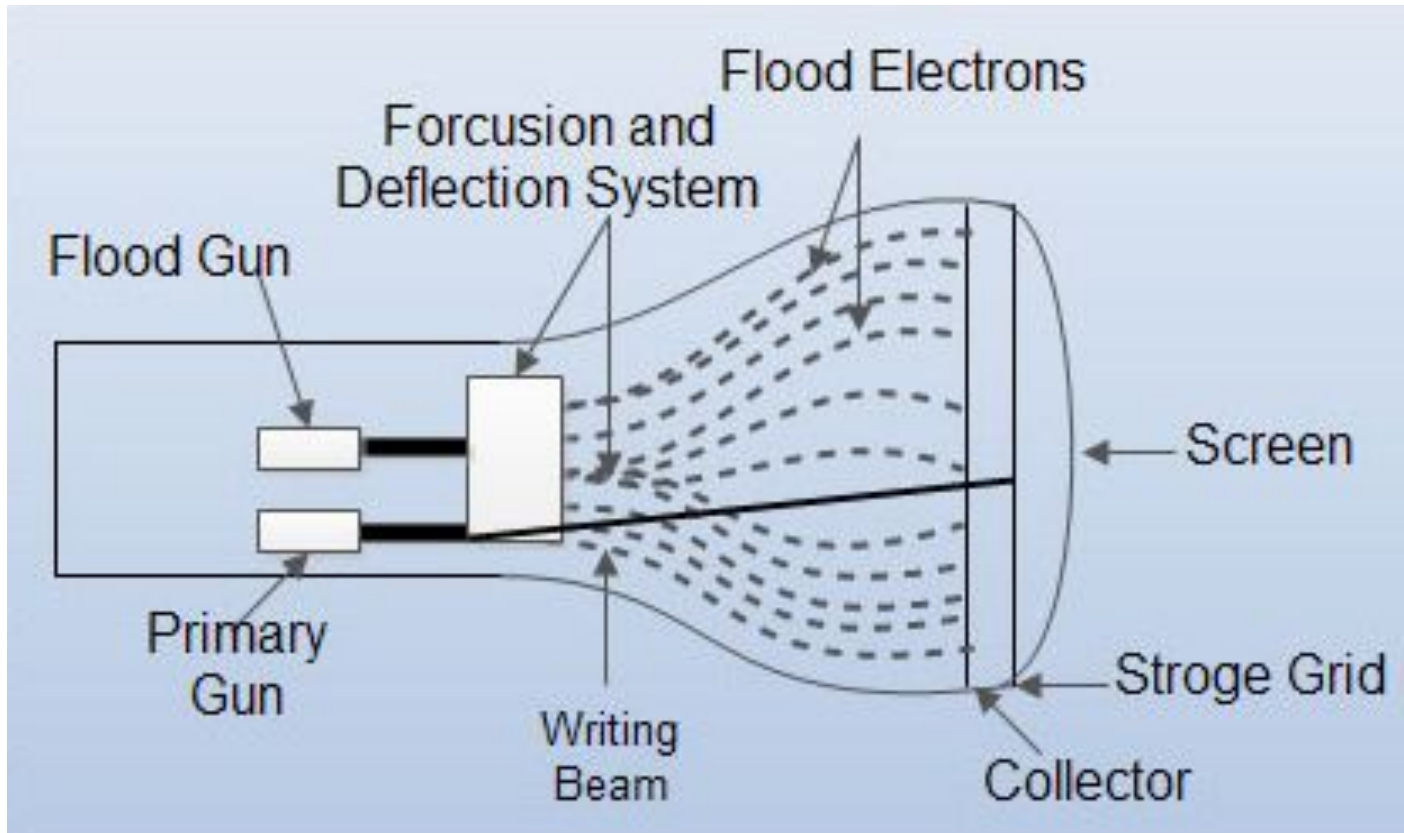
DVST

DVST

- **DVST:**
  - DVST consists of two guns: **Primary gun** and **Flood gun**.

  - A primary gun stores the picture pattern and the flood gun maintains the picture display.

  - A **primary gun** produces high speed electrons which strike on the storage grid to draw the picture pattern.

  - Continuous low speed electrons from **flood gun** pass through the control grid and attracted to the positive charged areas of the storage grid.

DVST

- **DVST:**
  - The low speed electrons then penetrate the storage grid and strike the phosphor coating.

  - During this process collector behind the storage grid smooth out the flows of flood electrons.

DVST

- **DVST:**
  - Advantages :
    - Refreshing of CRT is not required.
    - Complex picture can be displayed on high resolution.
    - It has flat screen.
  - Disadvantages:
    - Erasing requires removal of charge on the storage grid.
    - Selective or part erasing of screen is not possible.
    - The performance of DSTV is poor in compare to CRT.
    - Erasing of screen produces flash over the entire screen.

Flat Panel Display

- **Flat Panel Display:**
  - The term flat panel display refers to a class of video devices that have reduced volume, weight and power requirement in compared to a CRT.

  - The important feature of FPD is that they are thinner than CRTs.

  - There are two types of Flat panel display: **Emissive display** and **Non-emissive display**.

Flat Panel Display

- **Emissive Display:**
  - They convert electrical energy into light energy. Plasma panels, thin-film displays, and light emitting diodes are example of emissive displays.

- **Non-emissive Display:**
  - They use optical effect to convert sunlight or light from some other source into graphics patterns. Liquid crystal display is an example of non-emissive display.

Plasma Panel Display

- **Plasma Panel Display:**
  - Plasma panel display writes images on the display surface point by point, each point remains bright.

  - This makes the plasma panel functionally very similar to the DVST.

  - It consist of two plates of glass with thin, closely spaced gold electrodes.

  - The electrodes are attached to the inner faces and covered with a dielectric material.

Plasma Panel Display
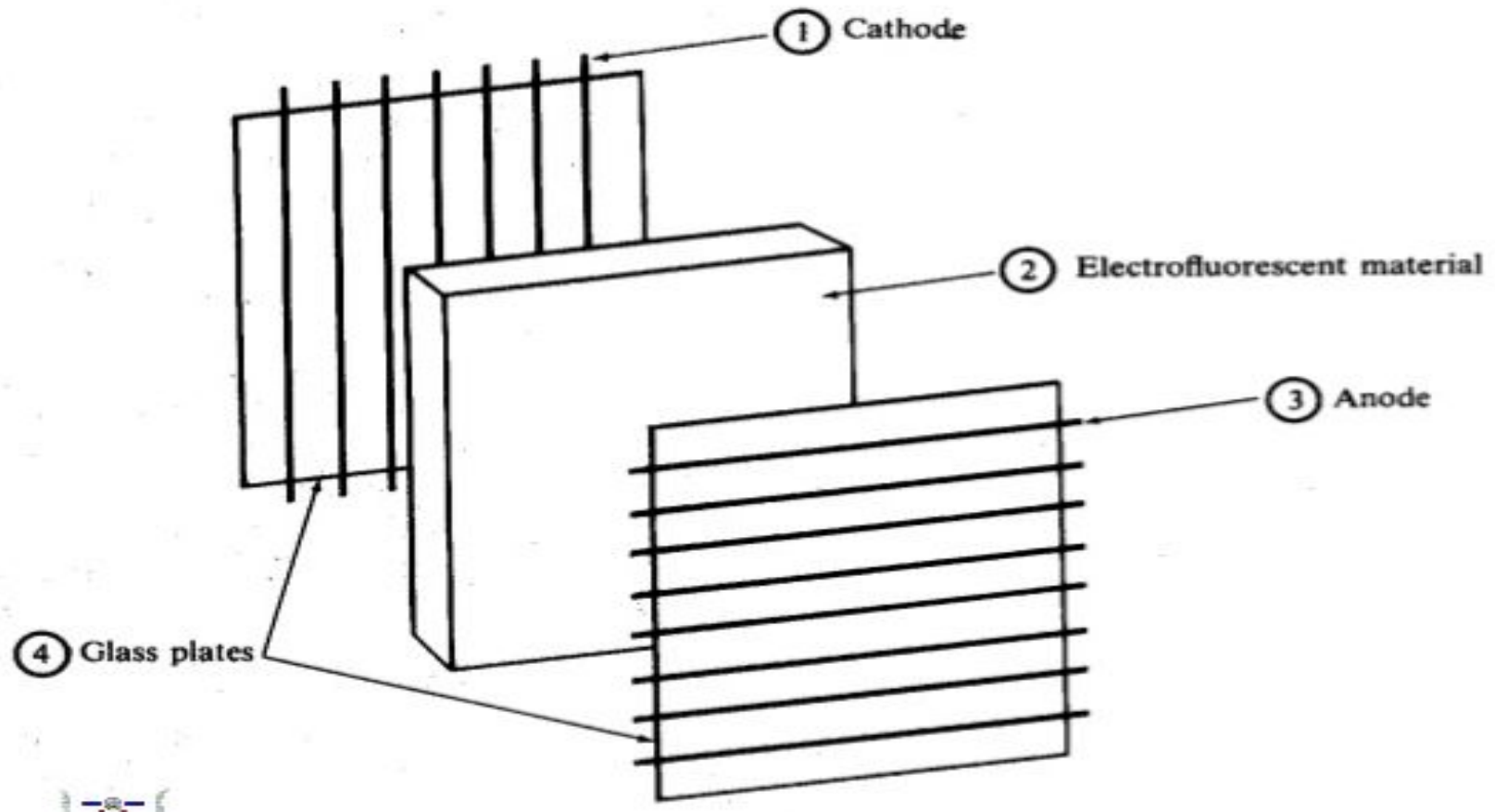
Plasma Panel Display

Plasma Panel Display

- **Plasma Panel Display:**
  - These are attached to as a vertical ribbons on one glass plate, and a set of horizontal ribbons to the other glass plate.

  - The space between two glass plates is filled with neon-based gas and sealed. By applying voltage between the electrodes the gas within the panel is made to behave as if it were divided into tiny cells.

  - Refreshing is not required in this display.

Plasma Panel Display

- **Advantages:**
  - Refreshing is not required.
  - Produce very steady image.
  - Light weight than CRT
  - Allow selective writing and selective erasing.
 - Flat screen and is transparent.

- **Disadvantages:**
  - Poor resolution.
  - Complex addressing and wiring
  - Costly than CRTs.

LCD

- **Liquid Crystal Display:**
  - The term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid.

  - Two glass plates, each containing a light polarizer at right angles to the other plate sandwich the liquid-crystal material.

  - Rows of horizontal transparent conductors are built into one glass plate, and columns of vertical conductors are put into the other plate.

LCD
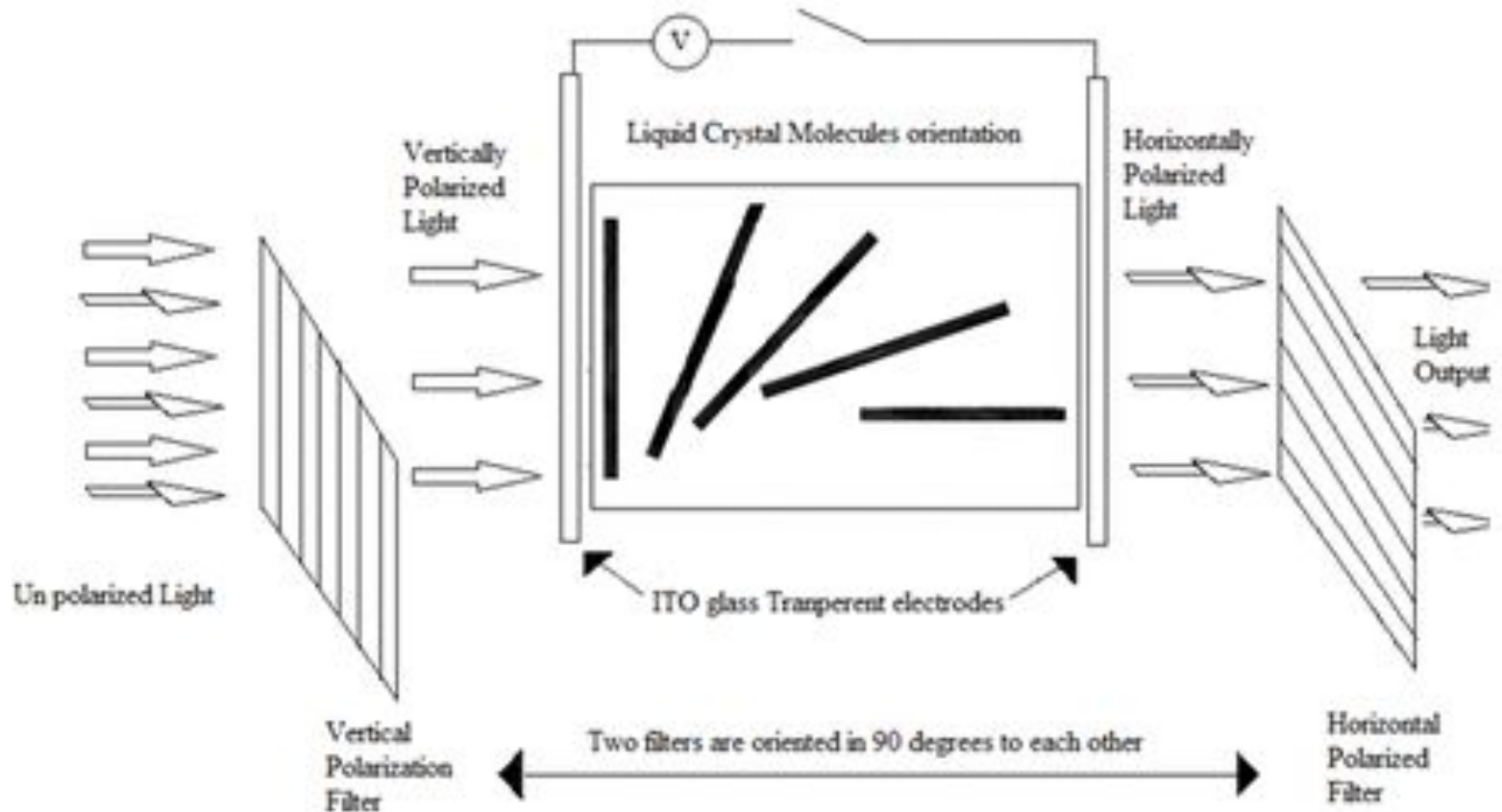
Liquid Crystal Display

LCD

- **Liquid Crystal Display:**
  - The intersection of two conductors defines a pixel position.

  - In the ON state, polarized light passing through material is twisted so that it will pass through the opposite polarizer.

  - It is then reflected back to the viewer.

  - To turn OFF the pixel, we apply a voltage to the two intersecting conductors to align the molecules so that light is not twisted.

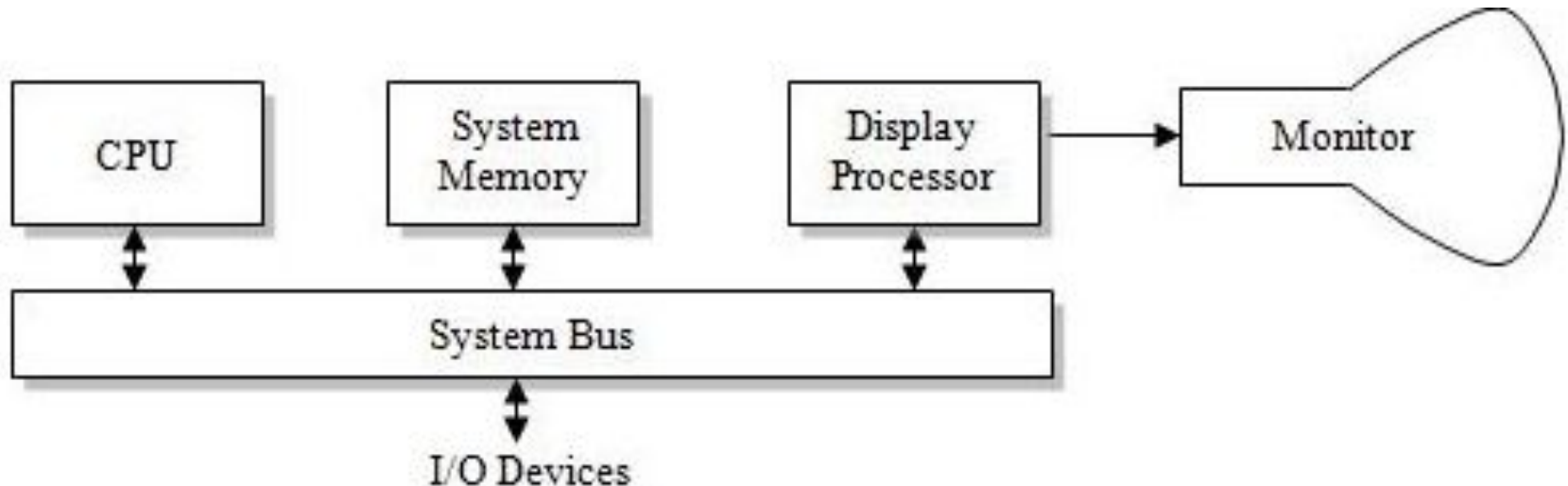# LCD

- **Advantages**
  - Low cost
  - Low weight
  - Small size
  - Low power consumption

Raster Scan System

Raster Scan System

- Hardware architecture of raster scan system is shown in figure.

- In addition to the general purpose CPU, a special-purpose processor, called the **video controller** or **display controller,** is used to control the operation of display device.
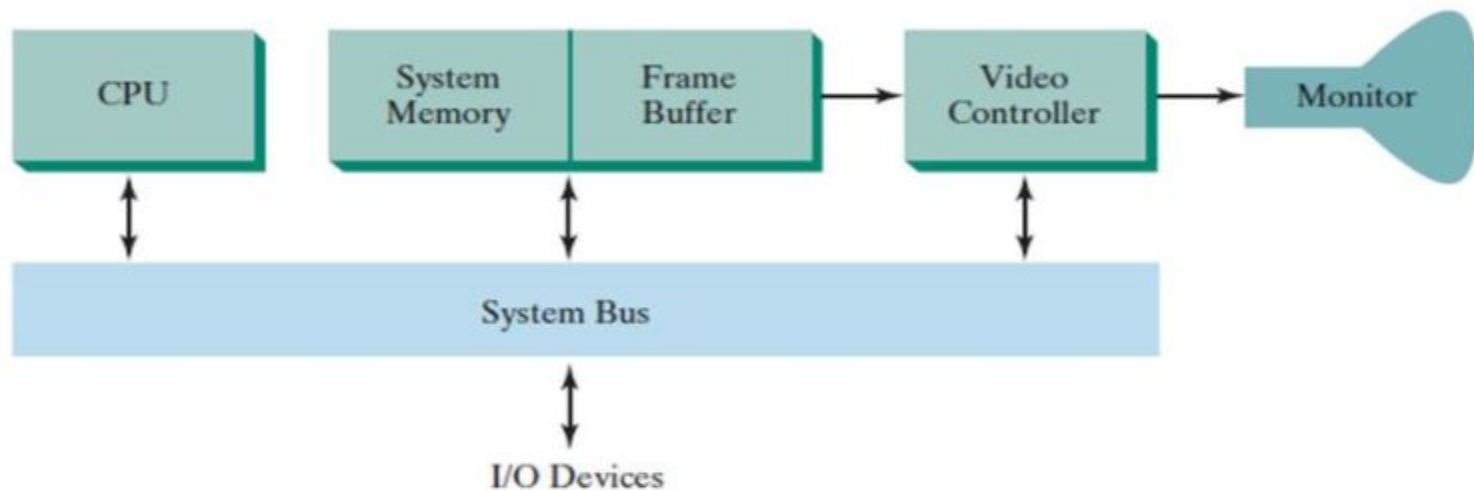
Raster Scan System

Raster Scan System

- In this architecture , frame buffer not allocated dedicated memory, System memory and frame buffer share the common memory area.

- Frame buffer can be anywhere in the system memory.

- Video controller reads the command from frame buffer and draw pixel accordingly.

Raster Scan System

Raster Scan System

Video Controller:

- Figure shows another variation of raster scan system. Dedicated memory area is allocated to frame buffer.

- Video controller is given direct access to frame buffer.

Raster Scan System

Raster Scan System

Video Controller:

• This organization can render scene quickly because video controller do not have to put request on system bus to read intensity value from frame buffer.

• In some system origin is set at bottom left location of screen. X coordinate increases from left to right and Y coordinate increases from bottom to top.

• In some system, origin is set at top left corner, Y coordinate increases on moving from top to bottom.
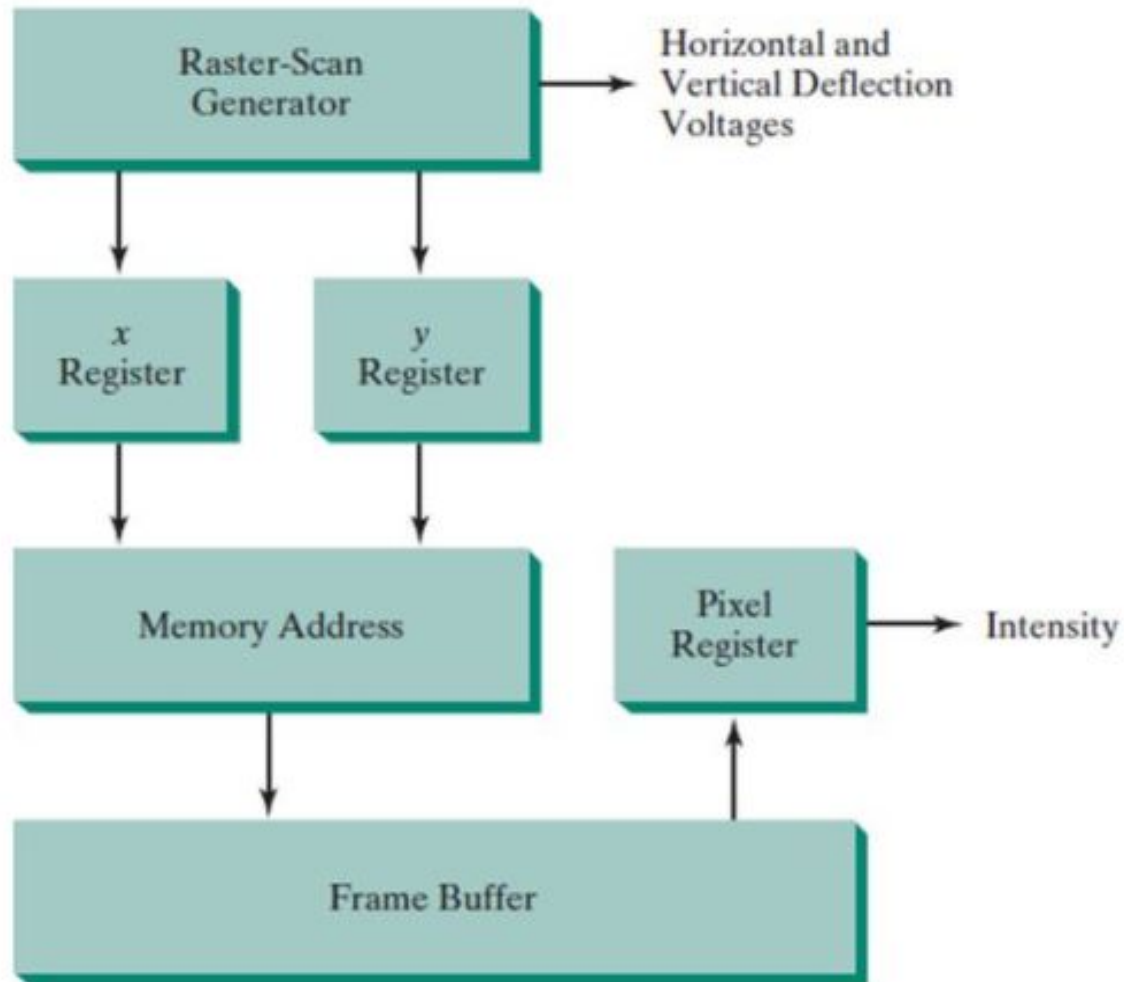
Raster Scan System

Raster Scan System

Video Controller:

- Intensity value from frame buffer is retrieved from current (x, y) location.

- After painting each pixel, x register is incremented by 1 and process is repeated until x value hit to x $_{max}$.

- After processing all pixel on current scan line, content of x register is set to zero, and y is incremented by 1and video controller process the scan line in same way.

- Refresh rate is 60 frames/seconds.

- Here in this discussion we assume that the origin is at top left of the corner of the screen.

Raster Scan System

Raster Scan System

# Raster Scan System

Raster Scan System

Video Controller:

- In high quality system use two frame buffers, so that one buffer can be used for refreshing while other is being filled.

- Then both buffer switch the role.

- This mechanism is useful in real time animation because it does not waste time in reloading the buffer.

Random Scan System

Random Scan System

- Hardware architecture of random scan system is shown in figure.
- Application program resides in system memory.
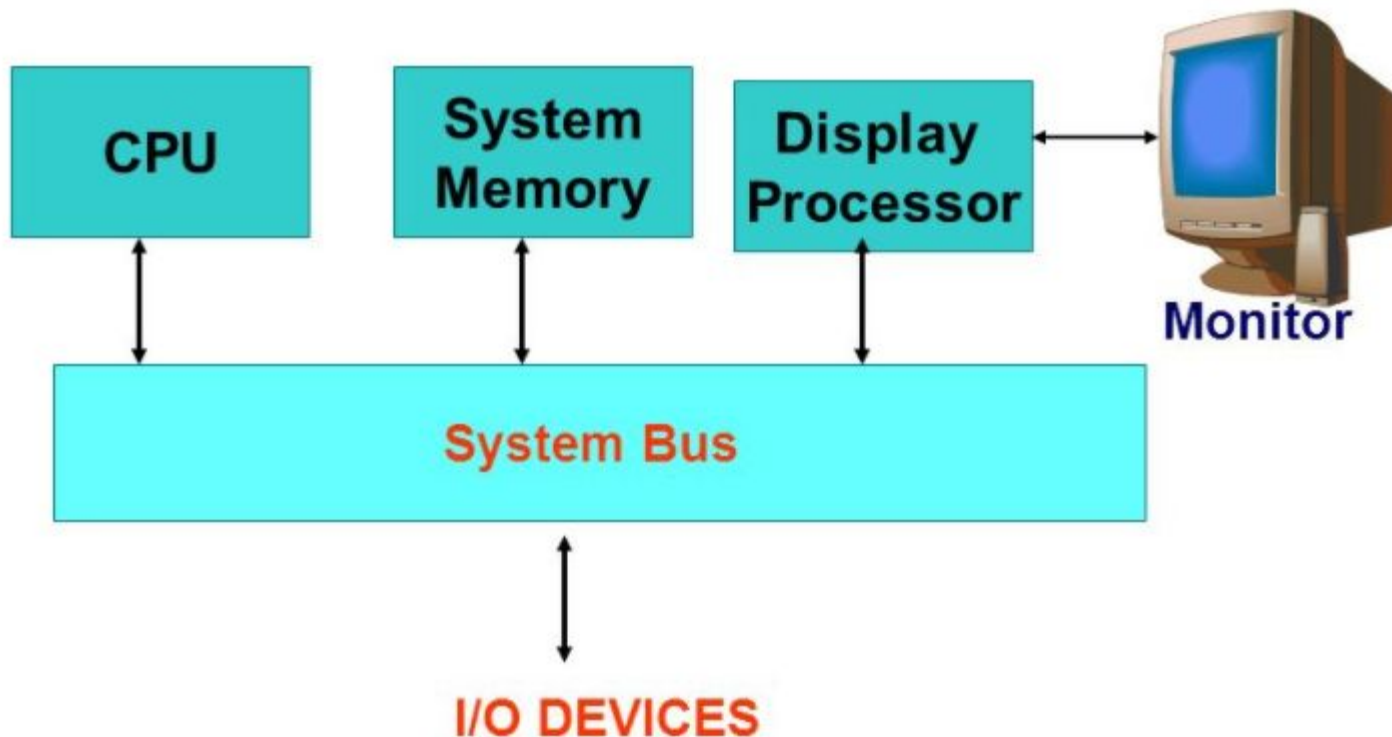
Random Scan System

Random Scan System

- Application program resides in system memory.

- Graphics packages translates the graphics commands in the application program into a display file.

- Display file also stored in system memory.

- Display processor accesses the content of display file and display on monitor screen.

- Display processor retrieves one by one command from display file and draws it on screen.

Random Scan System

Random Scan System

- Display processor in a random scan system is also called **graphics controller.**

- In random scan devices renders the scene using short line.

- Electron beam track the line position directly, rather than going through each and every pixel on screen.

- Entire scene is defined using segment of line in application program.

Random Scan System

Random Scan System

- Line segments are defined by pair of end points.

- A scene is then drawn one line at a time by positioning the beam to fill in the line between specified endpoints.

Differentiate Random Scan & Raster Scan System

No.	Raster Scan System	Random scan System
1	Electron beam scans entire screen to draw a picture	Electron beam scans only the part of screen where picture information is present.
2	It has low resolution.	It has high resolution in compare to raster scan.
3	Picture definition is stored as set of discrete intensity values in frame buffer.	Picture definition is stored as line drawing commands in display list.
4	Intensity value is sorted for each pixel, it displayed realistic scene.	System is designed to display lines, it can't displayed realistic scene.
5	Pixel location of screen is used to draw an image.	Mathematical function are used to draw an image.

Differentiate Random Scan & Raster Scan System

No.	Raster Scan System	Random scan System
6	Cheaper than random scan.	More costly.
7	Scan conversion is required.	Scan conversion is not required.
8	Video controller is required.	Video controller is not required.
9	Used to display dynamic scene.	Used to display static scene
10	Scan conversion hardware is required.	Scan conversion hardware is not required.
11	Refresh rate is independent of number of objects in scene.	When number of primitives are too large, random scan device flickers.

Graphics Input Devices
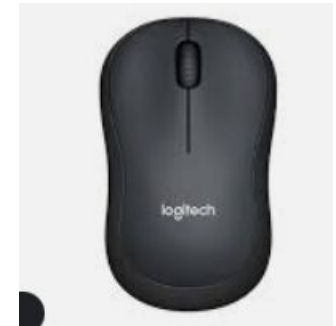
- Keyboards
- Mouse
- Trackball and Spaceball
- Joystick
- Data Glove
- Digitizer
- Image Scanners
- Touch Panels
- Light Pens
- Voice System

https://www.tutorialandexample.com/input-devices-in-computer-graphics

Keyboards

Input Devices

Trackballs and Spaceballs

- A **trackball** is a ball device that can be rotated with the fingers or palm of the hand to produce screen-cursor movement.

- An extension of the two-dimensional trackball concept is the **spaceball**, which provides six degrees of freedom. Unlike the trackball, a spaceball does not actually move.
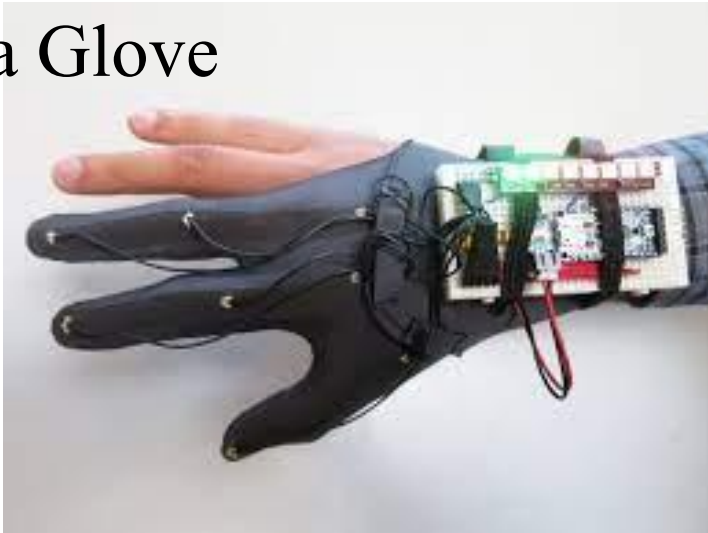
Joystick

Voice System

Data Glove

Touch Panels

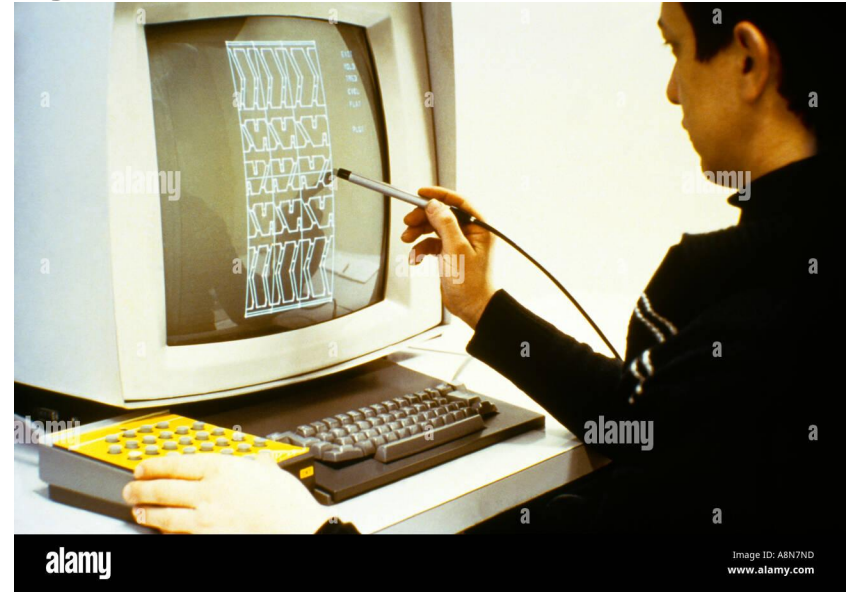# Digitizer

Light Pens

Image Scanners

Graphics Software and Standards

- **Graphics software** is classified in two categories:
  1. General Programming Packages
  2. Special-purpose applications Packages

1. General Programming Package:

They are like a programming languages, they contain rich set of graphics functions. Such graphics packages allow to draw some primitives, fill the colors, set the intensity, apply transformation etc. Open GL, Open CV is the examples of such packages. They are more of programmer oriented.

Graphics Software and Standards

2. Special-purpose applications Package:

By contrast, application graphics packages are designed for nonprogrammers, so users can create required graphics without worrying about underlying concepts. The interface to the graphics routines in such packages allow users to communicate with the programs in their own terms. Examples of such application packages are paint, CAD, maya 3D, photoshop etc.

THANK YOU