APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

STUDY MATERIALS

CS401 COMPUTER GRAPHICS

Module 1

Basic concepts in Computer Graphics – Types of Graphic Devices – Interactive Graphic inputs – Basic Raster Scan Graphics.

Introduction

The term **computer graphics** includes almost everything on computers that is not text or sound. Today almost every computer can do some graphics, and people have even come to expect to control their computer through icons and pictures rather than just by typing. Computer graphics is art of drawing pictures on computers, also called as rendering. The pictures can be photographs, drawings, movies, or simulations - pictures of things, which do not yet exist and maybe could never exist. Or they may be pictures from places we cannot see directly, such as medical images from inside your body.

Computer Graphics express data in pictorial form. It displays information in the form of graphics objects such as pictures, charts ,graphs etc instead of simply text. Computer graphics is an art of drawing pictures, lines, charts, etc using computers with the help of programming.It is the use of computer to define, store, manipulate, interrogate, and present pictorial output.

Applications of computer graphics

- Movie industry
- Games
- Medical Imaging and Scientific Visualization
- Computer Aided Design
- Education & training
- Simulators used for training ship captains,pilots
- Computer Art
- Presentation graphics
- Image processing
- GUI

Basic concepts in Computer Graphics

A display area is represented as a collection of discrete picture elements called pixels.Pixel is the smallest addressable unit on the screen. Each pixel has got some information like its intensity and color.

Interactive & Passive computer graphics

Basically there are two types of computer graphics namely Interactive Computer Graphics and Passive computer graphics .

Interactive Computer Graphics

It involves a two way communication between computer and user. The observer is given some control over the image by providing him with an input device .For example: Observer send his request to the computer through video game controller. Computer on receiving signals can modify the displayed picture appropriately.

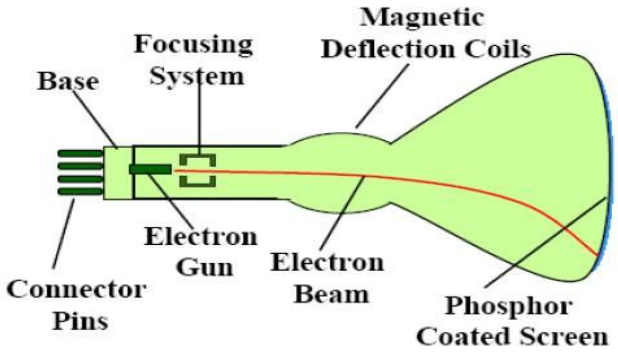
Non Interactive Computer Graphics

It is also known as passive computer graphics. The user does not have any kind of control over the image.It involves only a one way communication. The image is merely the product of static stored program and will work according to the instructions given in the program linearly. The image is totally under the control of program instructions, not under the user. Example: images shown on television.

Video Display Devices: CRT

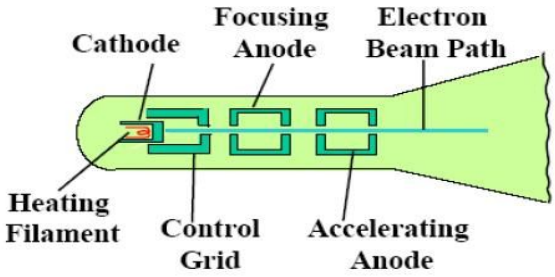
The primary output device in a graphics system is a video monitor.The operation of most video monitors is based on the standard cathode ray tube (CRT).

Working of Refresh CRT



The beam of electrons are emitted by an electron gun. It passes through focusing and deflection systems that direct the beam toward specified positions on the phosphor coated screen. Thus phosphor emits a small spot of light at each position contacted by the electron beam. Because the light emitted by the phosphor fades very rapidly, some method is needed for maintaining the screen picture. One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same points.This type of display is called a refresh CRT

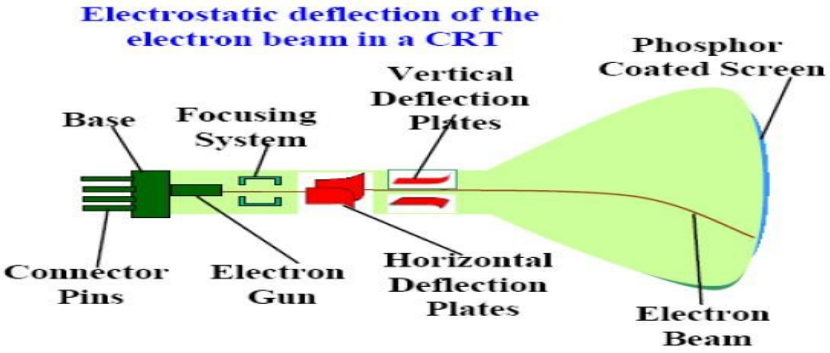
The primary components of an electron gun in a CRT are the heated metal , cathode and a control grid .



Heat is supplied to the cathode by directing a current through a coil of wire, called the filament.This causes electrons to be 'boiled off" the hot cathode surface. Intensity of the electron beam is controlled by setting voltage levels on the control grid, which is a metal cylinder that fits over the cathode. Amount of light emitted by the phosphor coating depends on the number of electrons striking the screen,thus we control the brightness of a display by varying the voltage on the control grid. A smaller negative voltage on the control grid simply decreases the number of electrons passing through the small hole at the end of the control grid structure. A high negative voltage applied will stop electrons from passing through it.

The focusing system force the electron beam to converge into a small spot as it strikes the phosphor. Otherwise, the electrons would repel each other, and the beam would spread out as it approaches the screen.Focusing is accomplished with the help of either electric or magnetic fields. It is commonly constructed with a pair of magnetic deflection coils mounted on CRT envelope.The magnetic field produced by each pair of coils directs the electron beam properly. Horizontal deflection is accomplished with one pair of coils, and vertical deflection by the other pair.

When electrostatic deflection is used, two pairs of parallel plates are mounted inside the CRT envelope. One pair of plates is mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control horizontal deflection



In the vacuum inside the CRT envelope, the free, negatively charged electrons are then accelerated toward the phosphor coating by a high positive voltage. The accelerating voltage can be generated with an accelerating anode or with a positively charged metal coating inside the CRT envelope near the phosphor screen.

When the electrons in the beam collide with the phosphor coating, they are stopped and their kinetic energy is absorbed by the phosphor. A part of the beam energy is converted by friction into heat energy, and the remainder causes electrons in the phosphor atoms to move up to higher

quantum energy levels. After a short time, the excited phosphor electrons begin dropping back to their stable ground state, giving up their extra energy as small quantum of Light energy. What we see on the screen is the combined effect of all these electron light emissions.

Basic concepts related to graphics display devices

Persistence :

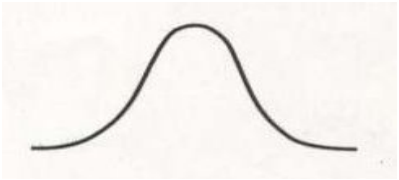
Persistence is defined as the time CRT takes to decay the emitted light from the screen to one tenth of its original intensity.Lower persistence phosphor require high refresh rate. Graphics monitors are usually constructed with a persistence in the range from 10 to 60 microseconds.

Resolution :

The maximum number of points that can be displayed without overlap on a CRT. The number of points per cm that can be plotted horizontally and vertically. Typical resolution on high-quality systems is 1280 by 1024. Higher resolution systems are often referred to as high-definition systems.

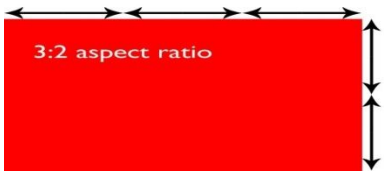
Intensity distribution :

Intensity is greatest at the center of pixel and decreases with Gaussian distribution towards edges.



Aspect Ratio :

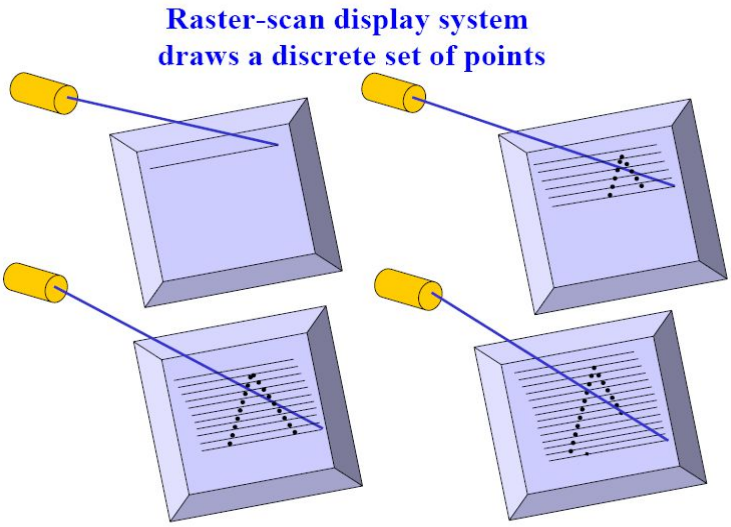
The ratio of vertical points to horizontal points necessary to produce equal length lines in both direction on the screen. It is the ratio of horizontal to vertical points.



Raster scan display and Random scan display.

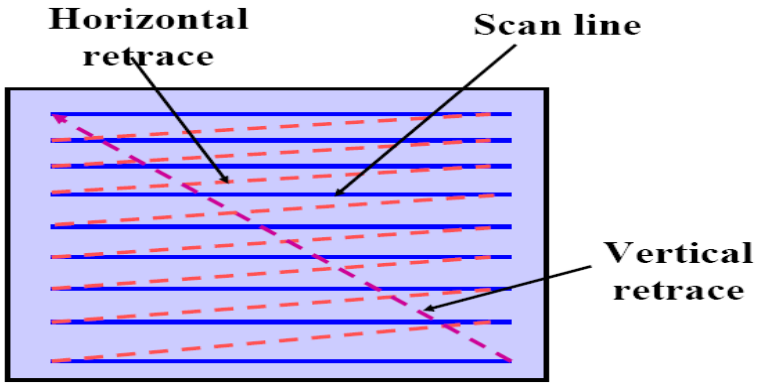
Raster scan display

It is the most common type of CRT monitor. In this system, the electron beam is swept across the screen one row at a time from top to bottom. Beam intensity is turned on and off to create a pattern of illuminated spots as the electron moves across each row .In a raster scan system entire screen is considered as a matrix of pixels. Each screen point is referred to as a pixel or pel (shortened form of picture element) .Frame buffer or refresh buffer is a memory where picture definition is stored .i.e set of all intensity values for all pixels is stored in refresh buffer.

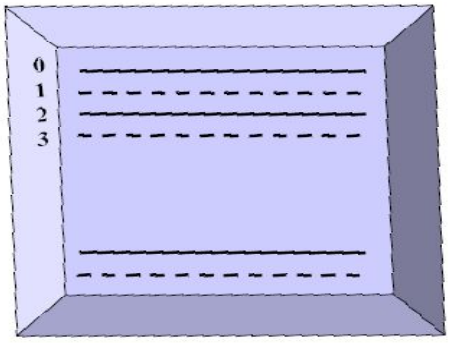


Horizontal Retrace: At the end of each scan line , the electron beam returns to the left side of the screen to begin displaying the next scan line.

Vertical retrace: At the end of each frame the electron beam returns to the top left corner of the screen to begin the next frame.



Interlacing: In this method, each frame is displayed in two passes using an interlaced refresh procedure.First all the points on the even numbered scanlines are displayed ,and then all the odd numbered lines are displayed. Entire screen is displayed in half time , providing that adjacent scanlines contain similar information.



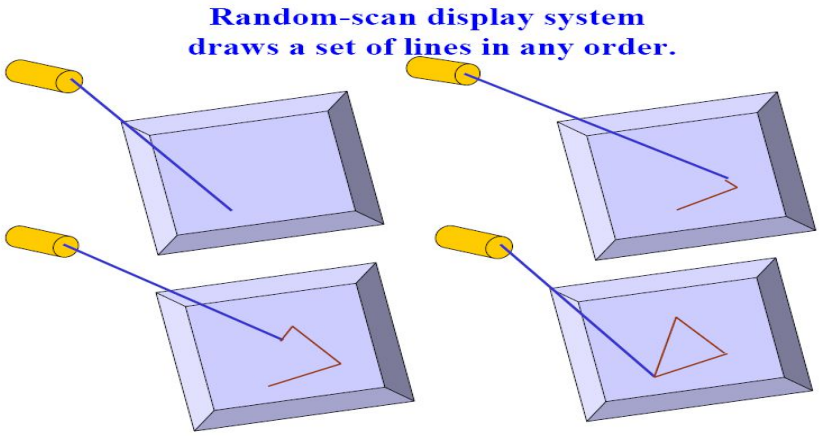
In a simple black and white system, each screen point is either on or off, so only one bit per pixel is needed to control the intensity of screen positions. Bit value of 1 indicates that the electron beam is to be turned on that position, and a value of 0 indicates that the beam intensity is to be turned off. Additional bits are needed when color and intensity variations are to be displayed .On a black-and-white system with one bit per pixel, the frame buffer is commonly called a bitmap. For systems with multiple bits per pixel, the frame buffer is referred to as a pixmap.

Refreshing on raster scan displays is carried out at the rate of 60 to 80 frames per second.Home television sets and printers are examples of other systems using raster-scan methods.The capability of a raster-scan system to store intensity information for each screen point makes it well suited for the realistic display of scenes containing subtle shading and color patterns.

Random scan display.

It is also called as calligraphic displays, vector displays, stroke displays.The electron beam is directed only to the parts of the screen where a picture is to be drawn.Random scan monitors draw a picture one line at a time. The component lines of a picture can be drawn and refreshed in any specified order.A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.

Picture definition is stored as a set of line drawing commands in an area of memory referred to as refresh display file/refresh buffer.To display a specified picture ,the system cycles through a set of commands in the display file , drawing each component line .After all line drawing commands have been processed, the system cycles back to the first line command in the list.



Random-scan displays are designed to draw all the component lines of a picture 30 to 60 times each second.Random-scan systems are designed for line drawing applications and cannot display realistic shaded scenes.

Raster displays	Random displays
Picture definition stored as set of intensity values	Picture definition stored as Line commands
Refreshing rate: 60 to 80 frames/sec	Refreshing rate: 30 to 60 frames/sec
Beam directed as continous scan line	Beam directed only to parts of image to be drawn
lower resolution	higher resolution
Draw Jagged lines	Draw Smooth lines
Example: printers	Example:plotters

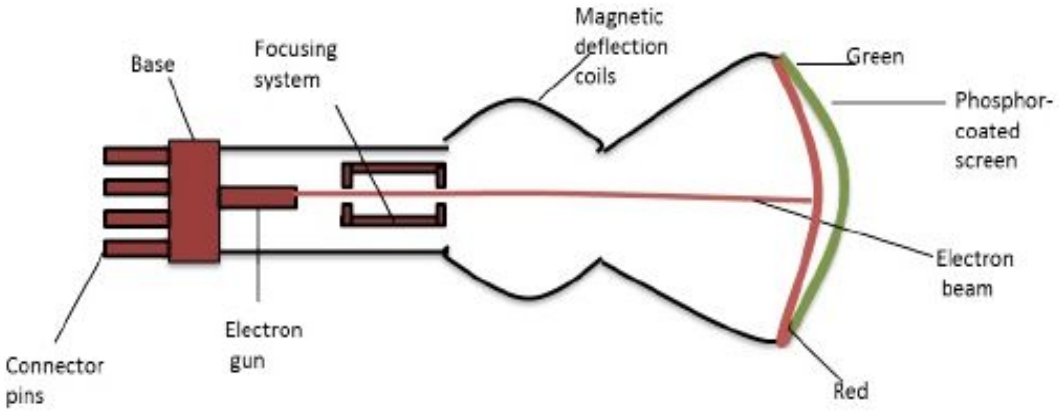
Color CRT

A CRT monitor displays color pictures by using a combination of phosphors that emit different-colored light. By combining the emitted light from the different phosphors, a range of colors can be generated. The two basic techniques are beam-penetration method and shadow-mask method.

Beam-penetration Method

In this method, two layers of phosphor, usually red and green, are coated onto the inside of the CRT screen. The displayed color depends on how far the electron beam penetrates into the phosphor layers. 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, combinations of red and green light are emitted to show two additional colors, orange and yellow. The

speed of the electrons, and hence the screen color at any point, is controlled by the beam-acceleration voltage.



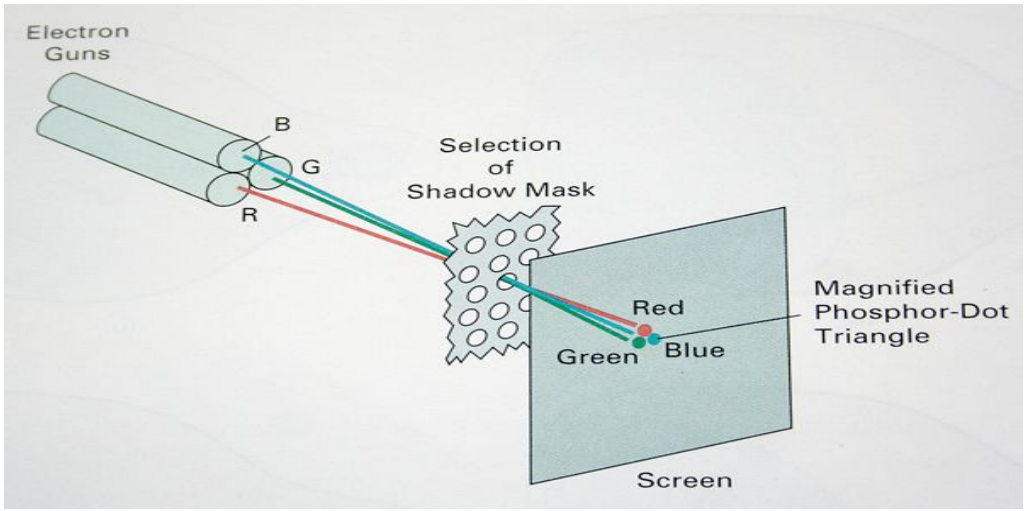
Advantage:

- An inexpensive way to produce color in random-scan monitors

Disadvantage:

- Only four colors are possible
- quality of pictures is not as good as with other methods.

Shadow-mask Method



This method is commonly used in color TV because they produce a much wider range of colors than the beam penetration method. A shadow-mask CRT has three phosphor color dots at each pixel position. One phosphor dot emits a red light, another emits a green light, and the third emits a blue light. This type of CRT has three electron guns, one for each color dot, and a shadow-mask grid just behind the phosphor-coated screen.

The three electron beams are deflected and focused as a group onto the shadow mask, which contains a series of holes aligned with the phosphor-dot patterns. When the three beams pass through a hole in the shadow mask, they activate a dot triangle, which appears as a small color spot on the screen. The phosphor dots in the triangles are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask. Color variations are obtained by varying the intensity levels of the three electron beams.

By turning off red and green guns, we get only blue phosphor. The color we see depends on the amount of excitation of the red, green, and blue phosphors.A white area is the result of activating all three dots with equal intensity.

Yellow -> green and red dots

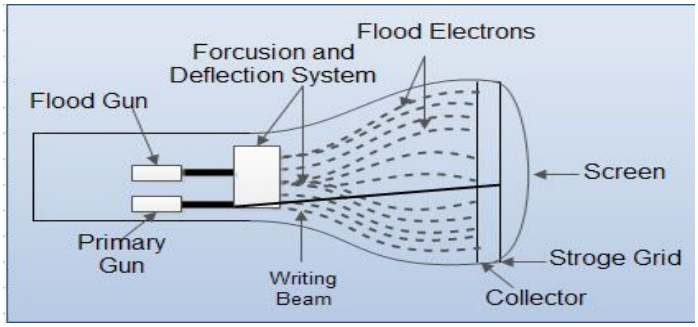
Magenta -> blue and red dots

Cyan ->blue and green

In some low-cost systems, the electron beam can only be set to on or off, limiting displays to eight colors. More sophisticated systems can set intermediate intensity levels for the electron beams, allowing several million different colors to be generated.

Direct-View Storage Tubes

An alternative method for maintaining a screen image is to store the picture information inside the CRT instead of refreshing the screen. A direct-view storage tube (DVST) stores the picture information as a charge distribution just behind the phosphor-coated screen. Two electron guns are used in a DVST- Primary gun & Flood gun. The Primary gun used to store the picture as pattern of positive charges on storage grid. The Flood gun used to maintains the picture display. Picture pattern is transferred to phosphor by continuous flood of electron generated from flood gun.Electrons are attracted by positively charged picture pattern on storage grid and are repelled by rest.The attracted electrons strike on phosphor making it visible on screen.



Advantages :

Because no refreshing is needed, very complex pictures can be displayed at very high resolutions without flicker.

Disadvantages :

- they ordinarily do not display color
- selected parts of a picture cannot be erased. To eliminate a picture section, the entire screen must be erased and the modified picture redrawn.

Flat Panel Displays

They are Video device that have reduced volume , weight and power requirement compared to a CRT. Flat Panel Displays are thinner than CRTs, and we can hang them on walls or wear them on our wrists. Some current uses are small TV monitors, calculators, pocket video games, laptop computers.

Emissive Displays And Nonemissive Displays

Displays are mainly classified in to two categories: Emissive Displays And Nonemissive Displays. Emissive displays (or emitters) are devices that convert electrical energy into light.

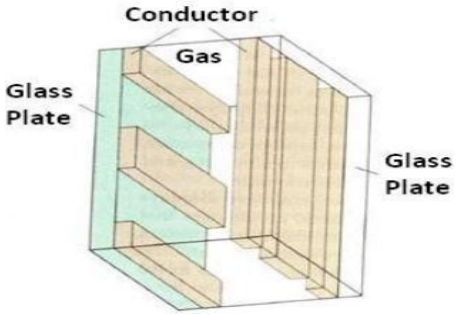
Eg: Plasma panels, light-emitting diodes (LED), thin-film electroluminescent displays

Nonemissive displays (or nonemitters) use optical effects to convert sunlight or light from some other source into graphics patterns.

Eg: liquid-crystal device (LCD)

Plasma panels

It is also called as gas-discharge displays.It is constructed by filling the region between two glass plates with a mixture of gases that usually includes neon.A series of vertical conducting ribbons is placed on one glass panel and a set of horizontal ribbons is built into the other glass panel.



Firing voltages applied to a pair of horizontal and vertical conductors cause the gas at the intersection of the two conductors to break down into a glowing plasma of electrons and ions. Picture definition is stored in a refresh buffer, and the firing voltages are applied to refresh the pixel positions 60 times per second.

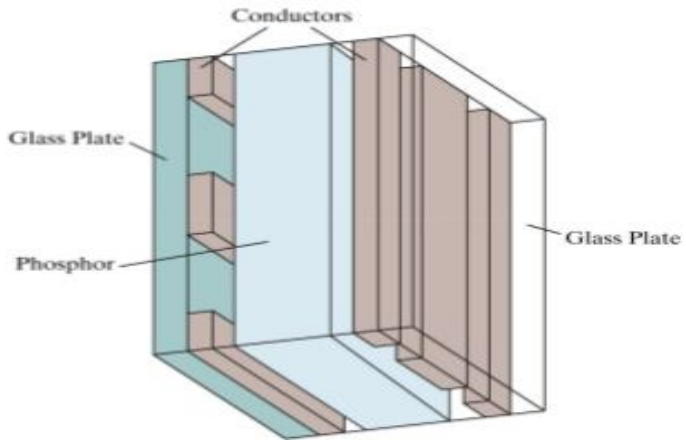
Disadvantage : they were strictly monochromatic devices.(but now systems have been developed capable of displaying color and grayscale).

Thin-film Electroluminescent Displays

It has got similar construction compared to a plasma panel. The region between the glass plates is filled with a phosphor, such as zinc sulfide doped with manganese, instead of a gas. When a sufficiently high voltage is applied to a pair of crossing electrodes, the phosphor becomes a conductor in the area of the intersection of the two electrodes. Electrical energy is then absorbed by the manganese atoms, which then release the energy as a spot of light similar to the glowing plasma effect in a plasma panel.

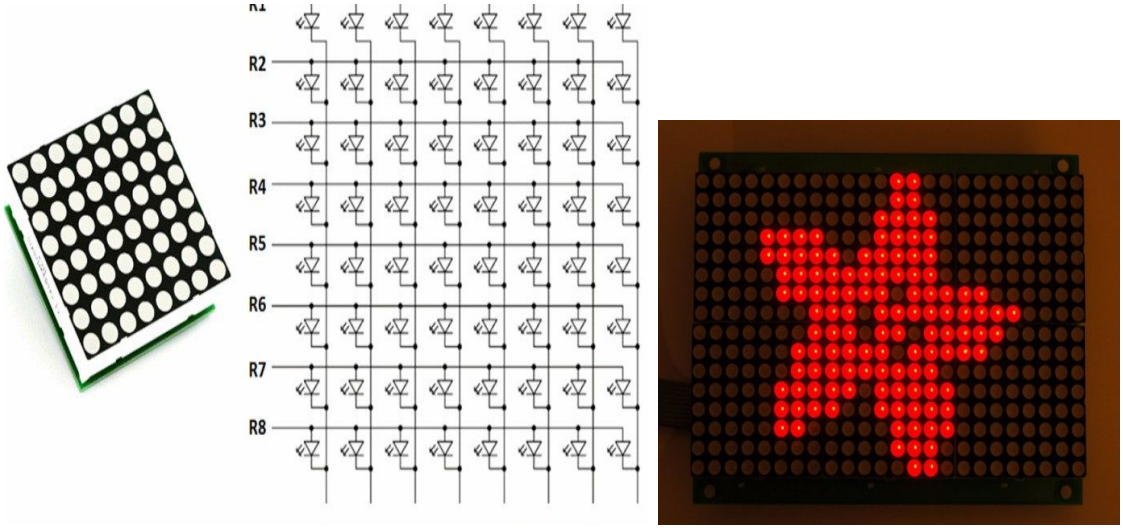
Disadvantage:

- require more power than plasma panels
- good color and gray scale displays are hard to achieve.



Light-emitting Diode (LED)

In LED, a matrix of diodes is arranged to form the pixel positions in the display. The picture definition is stored in a refresh buffer. Information is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light patterns in the display.

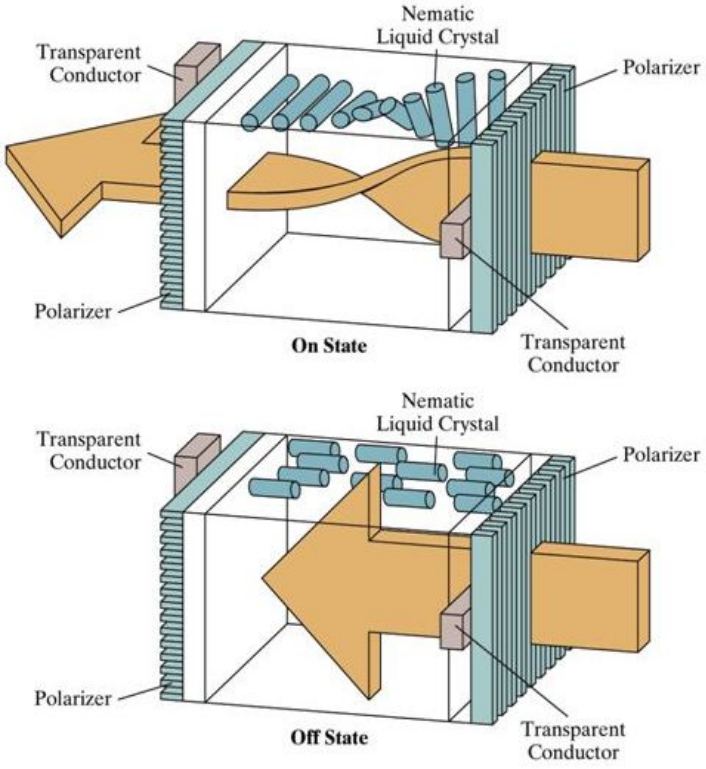


Liquid-crystal Displays (LCDs)

It is a non-emissive devices .i.e it uses source of light to form graphics patterns. They are commonly used in calculators and portable laptop computers. It produce a picture by passing polarized light from the surroundings or from an internal light source through a liquid-crystal material that can be aligned to either block or transmit the light. Flat-panel displays commonly use nematic (threadlike) liquid-crystal compounds that tend to keep the long axes of the rod-shaped molecules aligned.

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. The intersection of two conductors defines a pixel position. Normally, the molecules are aligned as shown in the "on state“.Polarized light passing through the material is twisted so that it will pass through the opposite polarizer . To turn off the pixel,

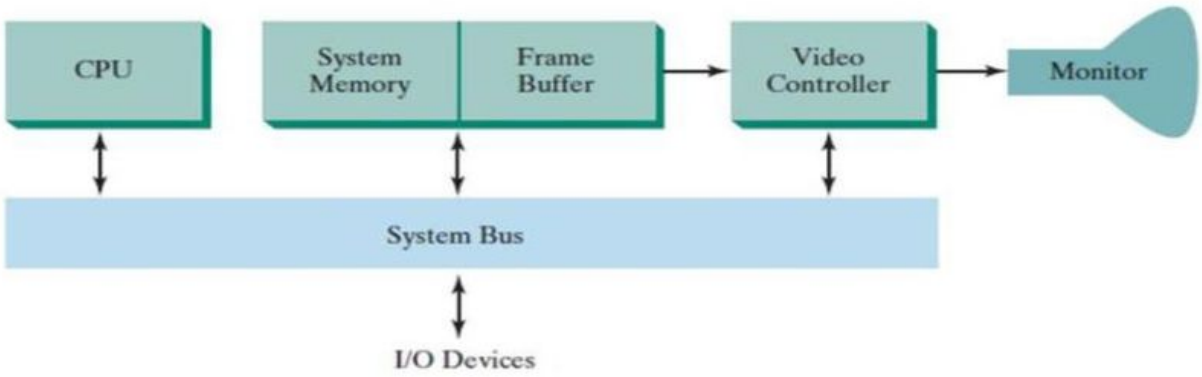
we apply a voltage to the two intersecting conductors to allign the molecules so that the light is not twisted. This type of flat-panel device is referred to as a passive-matrix LCD. Picture definitions are stored in a refresh buffer, and the screen is refreshed at the rate of 60 frames per second.



RASTER& RANDOM SCAN SYSTEMS

RASTER-SCAN SYSTEMS

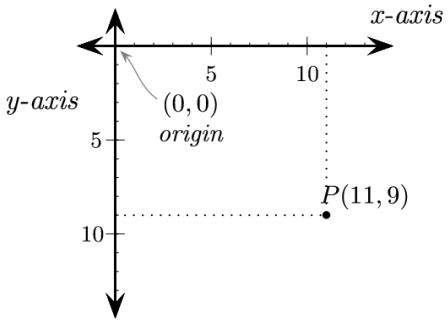
In Interactive raster graphics systems, in addition to the CPU ,a special-purpose processor, called the video controller or display controller, is used to control the operation of the display device.



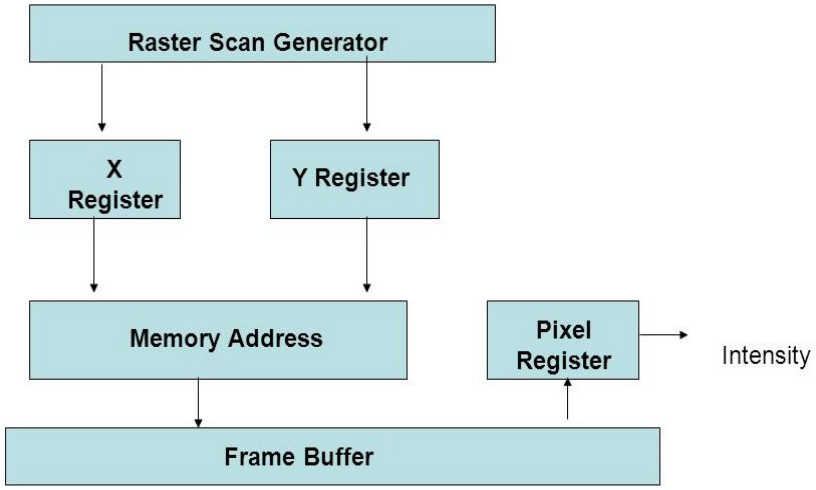
A fixed area of the system memory is reserved for the frame buffer, and the video controller is given direct access to the frame-buffer memory. Frame-buffer locations, and the corresponding screen positions, are referenced in Cartesian coordinates.

For many graphics monitors, the coordinate origin is defined at the lower left screen corner .The screen surface is represented as the first quadrant of a two-dimensional system, with positive x values increasing to the right and positive y values increasing from bottom to top.Scan lines are then labeled from y_{max} at the top of the screen to 0 at the bottom. Along each scan line, screen pixel positions are labeled from 0 to x_{max}.

On some personal computers, the coordinate origin is referenced at the upper left comer of the screen, so the y values are inverted.



Basic refresh operations of the video controller



Two registers are used to store the coordinates of the screen pixels: x register and y register. Initially, x register is set to 0 and the y register is set to y_{max}. The value stored in the frame buffer for this

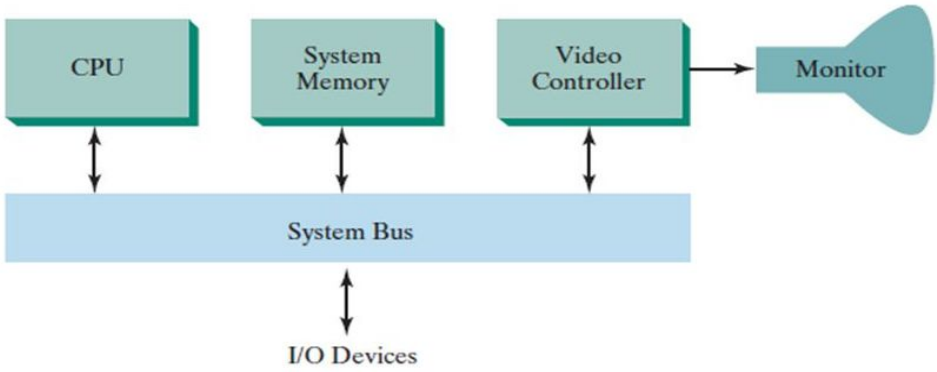
pixel position is then retrieved and used to set the intensity of the CRT beam. Then the x register is incremented by 1, and the process repeated for the next pixel on the top scan line. This procedure is repeated for each pixel along the scan line. After the last pixel on the top scan line has been processed, the x register is reset to 0 and the y register is decremented by 1. Pixels along this scan line are then processed in turn, and the procedure is repeated for each successive scan line. After cycling through all pixels along the bottom scan line (y = 0), the video controller resets the registers to the first pixel position on the top scan line and the refresh process starts over.

To speed up pixel processing, video controllers can retrieve multiple pixel values from the refresh buffer on each pass. The multiple pixel intensities are then stored in a separate register called pixel register and used to control the CRT beam intensity for a group of adjacent pixels.

Organization of a raster system containing a separate display processor, sometimes referred to as a graphics controller or a display coprocessor. The purpose of the display processor is to free the CPU from the graphics chores.

In addition to the system memory, a separate display processor memory area can also be provided. Main purpose is digitizing a picture definition given in an application program into a set of pixel-intensity values for storage in the frame buffer. This digitization process is called scan conversion.

RANDOM-SCAN SYSTEMS



An application program is input and stored in the system memory along with a graphics package. Graphics commands in the application program are translated by the graphics package into a display file stored in the system memory. This display file is then accessed by the display processor to refresh the screen. The display processor cycles through each command in the display file program once during every refresh cycle. Sometimes the display processor in a random-scan system is referred to as a display processing unit or a graphics controller.

Graphics patterns are drawn on a random-scan system by directing the electron beam along the component lines of the picture. Lines are defined by the values for their coordinate endpoints, and these input coordinate values are converted to x and y deflection voltages. A scene is then drawn one line at a time by positioning the beam to fill in the line between specified endpoints.

Important questions:

1. Define computer graphics. Briefly explain any three applications of computer graphics.
2. Explain two ways to store color information in frame buffer?

Color-information can be stored in the frame buffer in two ways: We can store color codes directly in the frame buffer, or we can put the color codes in a separate table and use pixel values as an index into this table. With the direct storage scheme, whenever a particular color code is specified in an application program, the corresponding binary value is placed in the frame buffer for each-component pixel in the output primitives to be displayed in that color. Color tables are an alternate means for providing extended color capabilities to a user without requiring large frame buffers. Lower cost personal computer systems, in particular, often use color tables to reduce frame-buffer storage requirements.

3. Write a note on pointing input devices.

Pointing Devices are used for providing input to computer by moving device to point to a location on computer monitor . Input data is not typed. Data is entered by moving pointing device .Cursor on computer monitor moves with the moving pointing device .Operations like Move, click and drag can be performed.

E.g. Mouse, trackball, joystick, digitizing tablet

a. Mouse

Data entered by pointing mouse to a location on computer screen .Used to position cursor on screen, move object by dragging, select object by clicking. Cursor moves with mouse. So it can be positioned at any location on screen by moving mouse .Provides easy way to select and choose commands from menus, dialog boxes, icons .Used extensively, while working with graphics elements such as line, curve, shapes etc.

- Description of Mouse

Small hand held device having two or three buttons on upper side. Has a small wheel between buttons for up & down movement. Mainly Classified as: Physical mouse, Optical mouse, Bluetooth mouse

i. *Physical mouse:* Has a rubber ball on bottom side. Requires smooth, dust free surface on which it is rolled
ii. *Optical mouse*: Uses LED and sensor to detect mouse movement. Requires flat surface underneath it. No moving part. Introduced by Microsoft in 1999
iii. *Bluetooth Mouse*: Connects with the computer using Bluetooth instead of a data cable

- Mouse actions
  - Pointing
  - Left Click or Click
  - Right Click
  - Double Click
  - Drag and Drop

b.Track Ball

Variant of mouse. It has functionality of mouse. Easy to use, takes less space than mouse. Usually built into laptops .It requires ball to be rotated manually with finger. Device remains stationary .Cursor on computer screen moves in direction in which ball moved. Buttons are used in same way as mouse buttons .

c.Digitizing Tablet

They are used to input drawings, sketches; Used for CAD to design buildings, automotives, maps. It consists of two parts; Electronic tablet: Flat bed tablet. Each position on tablet corresponds to fixed position on screen and Pen: Looks like ball pen but has electronic head. Pen moved on tablet .It can detect movement of pen on tablet, convert movement into digital signals, send digital signal to computer

d.Joystick

They are commonly used for playing video games. Used to control speed of cursor .Direction of push of stick and amount of deflection determines change in position and change in speed, respectively.

4. Explain technologies used in Raster scan & Random scan displays.
5. Explain gata generation devices
6. What is scan conversion
7. Explain any two graphical input devices
8. Define aspect ratio of input devices
9. Define refresh buffer
10. Explain antialiasing

    Antialiasing is the smoothing of the image or sound roughness caused by aliasing(jagged edge, or stair-step effect) . With images, approaches include adjusting pixel positions or setting pixel intensities so that there is a more gradual transition between the color of a line and the background color. Different techniques are super sampling, area sampling & pixel phasing.
11. Explain the purpose of display processor
12. Explain rastor scan system
13. List the operating characteristics for the following display technologies: raster refresh systems, vector refresh systems(random), plasma panels.
14. What is the role of a display controller in raster scan display system? Explain
15. How is frame buffer loading performed
16. Define resolution of video monitor
17. Explain the working of mouse
18. Explain hard copy devices

    Hard copy devices are used to create hard copy output.Output in tangible form on paper, any surface .It Can be stored permanently, portable .It can be read or used without computer .Devices that generate hard copy output

    E.g. Printer, Plotter, Microfiche

    a. Printer

    Prints output information from computer onto paper.Used to print textual information, graphical information .Print quality is determined by resolution of printer (dpi). High resolution provides better quality output.

    Classified as: impact printer, non-impact printer

    - Impact Printer

    Uses typewriter approach of physically striking typeface against paper and inked ribbon Print character, entire line at a time .Low-cost printers useful for bulk printing

    E.g. Dot matrix printer, daisy wheel printer, drum printer

    - Types of Impact Printer

    Dot matrix printers - print one character at a time .In two sizes – 80 column, 132 column. Can print only in black and white. Used in payroll and accounting applications.

    Daisy wheel printers - print one character at a time. Produce letter quality document. Better than dot matrix printer. Print head like a daisy flower. Slow, can print text, costly. Used for high quality printing

    Drum printers - line printers.Expensive, faster than character printers. Produce low quality output. Used for voluminous print outputs

    - Non-Impact Printers

    Do not hit or impact ribbon to print .Use electro-static chemicals, ink-jet technologies.Faster and quieter than impact printers .Produce high quality output .Can print text, graphics both in black & white, color

E.g. Ink-jet printer, laser printer

- Types of Non-impact Printer

Ink-jet printers - Spray ink drops directly on paper like a jet .Resolution more than 500 dpi .Produce high quality graphics and text .Used in homes and offices

Laser printers - provide highest quality of text, graphics printing .Process, store page before printing. *Page printers* .Can print 5-24 pages of text per minute. Resolution - 400-1200 dpi.Faster, expensive than impact printers .Used for high quality voluminous printing

b. Plotter

Used for vector graphics output to draw graphs, maps, blueprints of ships, buildings.Use pens of different colors for drawing .Draw continuous, accurate lines. Slow. Expensive

Two kinds – drum plotter and flatbed plotter

Drum plotter - Pens mounted on carriage stationary. Moves horizontally. For vertical movement, drum moves clockwise and anti-clockwise

Flat bed plotter – paper fixed on flat bed, stationary. Pens mounted on carriage move horizontally and vertically to draw lines. Used for AUTOCAD, CAD

19. Explain the advantage of interlace display operations in ranster scan displays.
20. Explain two methods used in color CRT.
21. Explain the working of refresh CRT
22. Explain interactive and non interactive devices
23. Explain emissive and non emissive displays
24. Explain the working principle of flat panel displays
25. Explain the working of LCD monitors
26. Explain the working of DVST.

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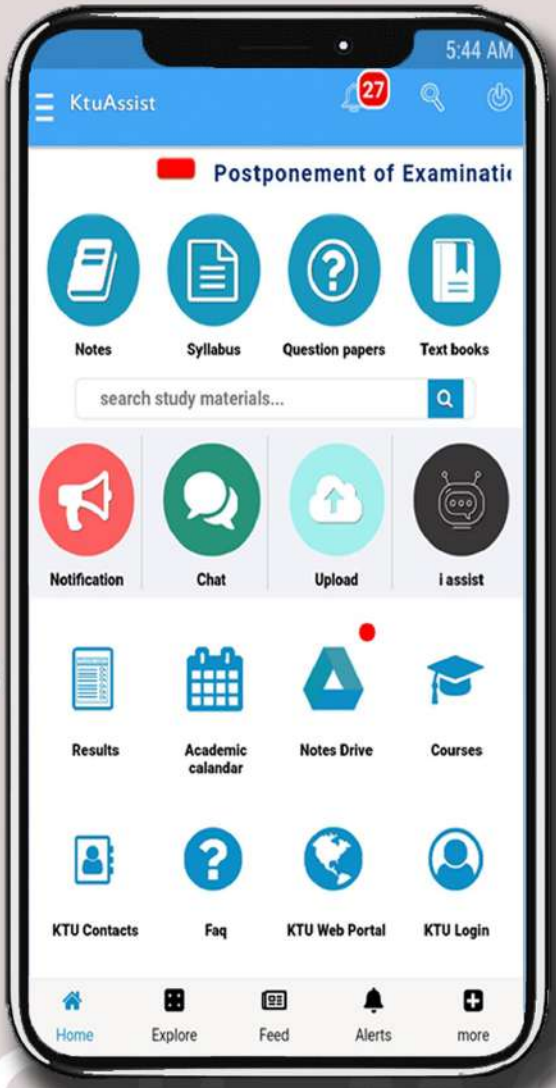

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