

Module I – Introduction CG

What is Computer Graphics?

-Using a computer as a rendering tool for the generation (from models) and manipulation of images is called *computer graphics*.

-Computer graphics is used today in many different areas of industry, business, government, education, entertainment, and most recently, the home.

-Computer graphics is the creation and manipulation of pictures with the aid of computer. There are two types of computer graphics.

Interactive computer graphics

Non-interactive graphics or passive computer graphics

Interactive computer graphics:

-The computer graphics in which the observer has some control over the image by providing him with an input device so that he can signal his request to computer. *Example: Video games.*

-Interactive computer graphics involves two way communications between computer and user. The user gives signals to computer through the input device and computer can modify the displayed picture accordingly.

Non-interactive computer graphics:

The computer graphics in which the observer has no control over the image. *Example: Titles shown on TV.*

Applications of Computer Graphics

Computers have become powerful tool for the rapid and economical production of pictures. Computer graphics are used in several areas such as

Computer aided design:

A major use of computer graphics is in design process particularly for engineering and architectural systems.

Computer aided design referred as CAD methods are now routinely used in the design of buildings, automobiles, aircraft, space craft and textiles etc.,

- Useful for testing performance of a vehicle.
- System in virtual reality environments.
- Realistic renderings of design process.
- Realistic 3D renderings of building designs.

Presentation Graphics:

Presentation graphics used to produce illustration for reports or generate 35mm slides etc., These graphics are commonly used to summarize and economic data for research reports, managerial reports, consumer information bulletins etc.,

Example: bar charts, line graphs and pie charts.

Computer art:

Computer graphics methods are widely used in both fine art and commercial art applications. Artists uses variety of computer methods including special purpose hardware, paint brush programs etc.,

Entertainment:

Computer graphics methods are now commonly used in making motion pictures, music videos and television shows.

Sometimes graphics are displayed by themselves i.e., computer animation and sometimes graphics objects are combined with the actors and live scenes.

Education and training:

Computer generated models of physical, financial and economic systems are often used as educational aids. For some training applications special system are designed.

Visualization:

Producing graphical representations for scientific, engineering and medical data sets and processes is generally referred to as *scientific visualization*. For

commerce, industry and other non-scientific areas data sets and processes is generally referred to as *business visualization*.

Image processing:

Image processing applies techniques to modify or interpret existing pictures such as photographs and TV scans. Two principal applications of image processing are

1. Improving picture quality
2. Machine perception of visual information as used in robotics.

Uses:

- To enhance the quality of a picture.
- In medical applications such as in tomography and in simulations of operations.

Graphical User Interfaces (GUI):

-The software packages provide a graphical interface. This provides a window manager that allows a user to display multiple window areas.

-Each window contains a different process that can contain graphical or non-graphical displays.

-To make a particular window active, we simply click in that window using an interactive pointing device.

-Interfaces also display menus and icons for fast selections for fast selection of processing operations.

Video Display Devices

The most common graphics output device is the video monitor which is based on the standard cathode ray tube (CRT) design, but several other technologies exist and solid state monitors may eventually predominate.

1. Refresh CRT

Basic Operation of CRT

Figure 1 illustrates the basic operation of a CRT. A beam of electrons (cathode rays), emitted by an electron gun, passes through focusing and deflection systems that direct the beam toward specified positions on the phosphor-coated screen.

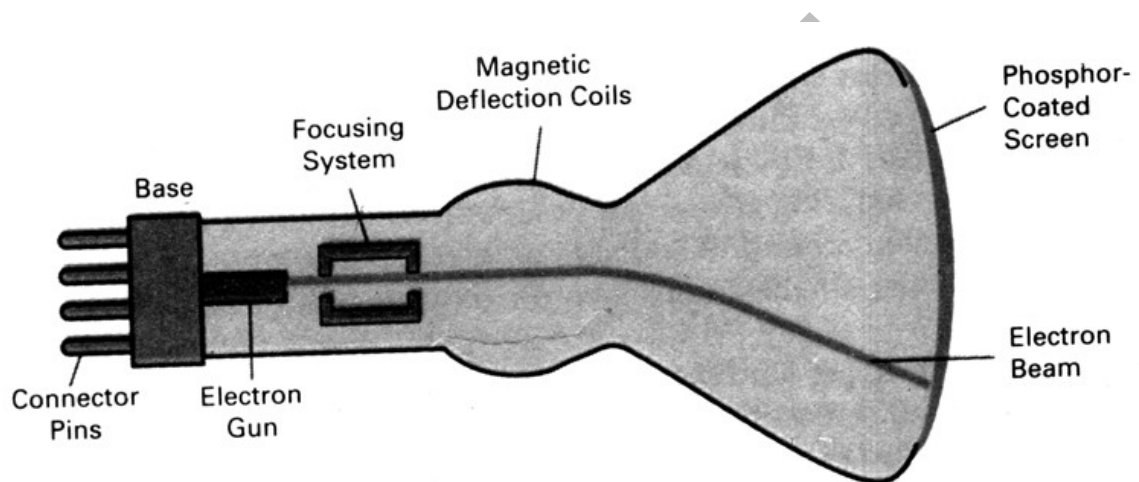


Figure 1: Basic Design of a magnetic-deflection CRT

The phosphor then 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.

Working

-Beam passes between two pairs of metal plates, one vertical and other horizontal. A voltage difference is applied to each pair of plates according to the amount that the beam is to be deflected in each direction. As the electron beam passes between each pair of plates, it is bent towards the plate with the higher positive voltage.

-In figure 2 the beam is first deflected towards one side of the screen. Then, as the beam passes through the horizontal plates, it is deflected towards, the top or bottom of the screen. To get the proper deflection, adjust the current through coils

placed around the outside of the CRT loop. The primary components of an electron gun in a CRT are the heated metal cathode and a control grid (Fig. 2).

- Heat is supplied to the cathode by directing a current through a coil of wire, called the filament, inside the cylindrical cathode structure. This causes electrons to be "boiled off" the hot cathode surface.

- 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 a positively charged metal coating on the inside of the CRT envelope near the phosphor screen, or an accelerating anode can be used, as in Fig. 2.

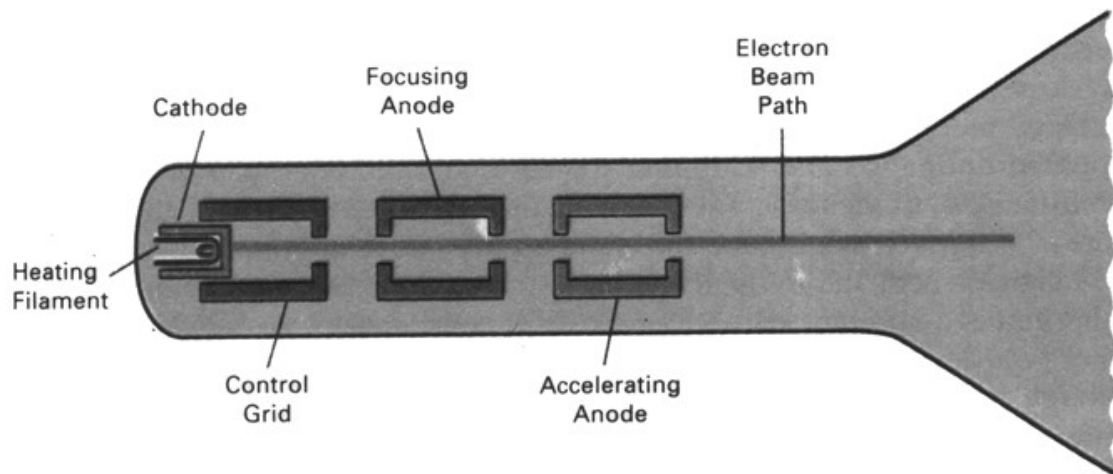


Figure 2: Operation of an electron gun with an acceleration anode

- The focusing system in a CRT is needed to force the electron beam to converge into a small spot as it strikes the phosphor.

- Focusing is accomplished with either electric or magnetic fields.

- Cathode-ray tubes are now commonly constructed with magnetic deflection coils mounted on the outside of the CRT envelope, as illustrated in Fig.1.

- Two pairs of coils are used, with the coils in each pair mounted on opposite sides of the neck of the CRT envelope. One pair is mounted on the top and bottom of the neck and the other pair is mounted on opposite sides of the neck.

- The magnetic field produced by each pair of coils results in a transverse deflection force that is perpendicular both to the direction of the magnetic field and to the direction of travel of the electron beam.

-Horizontal deflection is accomplished with one pair of coils, and vertical deflection by the other pair. The proper deflection amounts are attained by adjusting the current through the coils.

-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 (Fig.3).

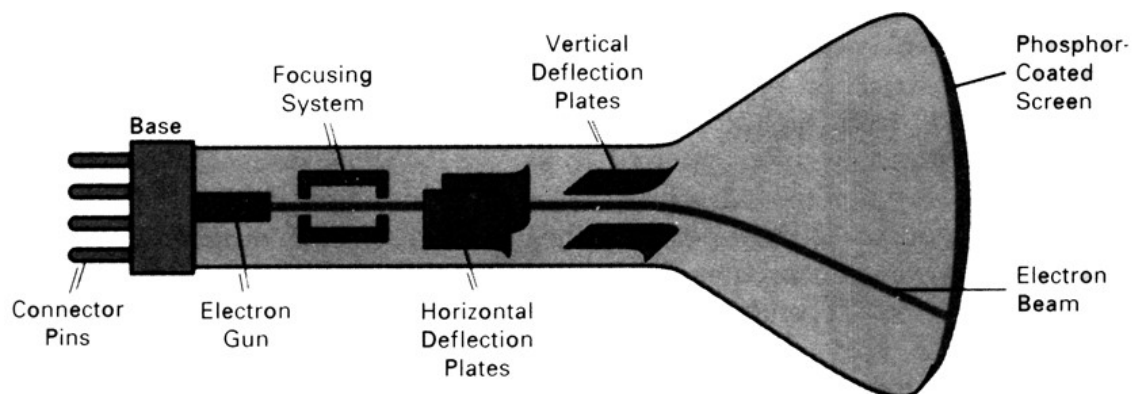


Figure 3: Electrostatic deflection of the electron beam in a CRT

Properties of CRT

Persistence- Persistence means how long they continue to emit light after the CRT beam is removed. It is defined as the time it takes the emitted light from screen to decay to one-tenth of its original intensity.

Resolution

The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution.

Aspect Ratio

Another property of video monitors is aspect ratio. This number gives the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen. (Sometimes aspect ratio is stated in terms of the ratio of horizontal to vertical points.)

An aspect ratio of 3/4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.

2. Raster scan and Random scan displays

Random scan display

-Random scan system uses an electron beam which operates like a pencil to create a line image on the CRT. The image is constructed out of a sequence of straight line segments.

-Each line segment is drawn on the screen by directing the beam to move from one point on screen to the next, where each point is defined by its x and y coordinates.

-After drawing the picture, the system cycles back to the first line and design all the lines of the picture 30 to 60 time each second.

-Random-scan monitors draw a picture one line at a time and for this reason are also referred to as vector displays (or stroke-writing or calligraphic displays) Fig. 4.

-A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.

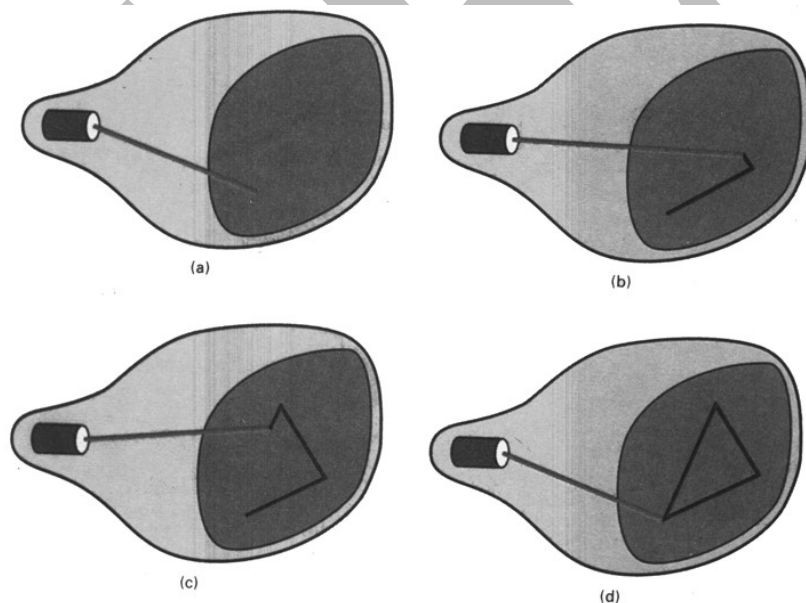


Figure 4: A random-scan system draws the component lines of an object in any order specified

-Refresh rate on a random-scan system depends on the number of lines to be displayed.

-Picture definition is now stored as a set of line-drawing commands in an area of memory referred to as the refresh display file.

-Random-scan systems are designed for line-drawing applications and cannot display realistic shaded scenes. Since picture definition is stored as a set of line-drawing instructions and not as a set of intensity values for all screen points, vector displays generally have higher resolution than raster systems.

-Also, vector displays produce smooth line drawings because the CRT beam directly follows the line path.

Raster-Scan Displays

-In raster scan approach, the viewing screen is divided into a large number of discrete phosphor picture elements, called pixels.

-Each pixel on the screen can be made to glow with a different brightness. Color screen provide for the pixels to have different colors as well as brightness.

-In a raster-scan system, the electron beam is swept across the screen, one row at a time from top to bottom. As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.

-Picture definition is stored in a memory area called the refresh buffer or frame buffer. This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and "painted" on the screen one row (scan line) at a time (Fig.6).

Each screen point is referred to as a pixel or pel (shortened forms of picture element). 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.

Home television sets and printers are examples of other systems using raster-scan methods.

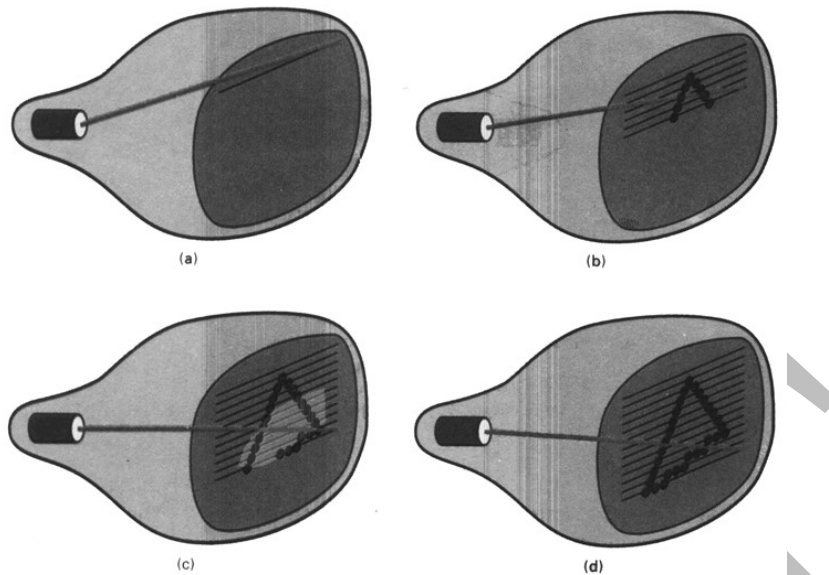


Figure 5: A raster-scan system displays an object as a set of discrete points across each scan line

Advantages

- produce realistic images
- produced different colors and shadows scenes.

Disadvantages

- low resolution
- expensive
- electron beam directed to whole screen

3. Color CRT Monitors

To display color pictures, combination of phosphorus is used that emits different colored light. There are two different techniques for producing color displays with a CRT.

1. Beam Penetration Method
2. Shadow Mask Method

Beam Penetration Method

The beam-penetration method for displaying color pictures has been used with random-scan monitors.

Two layers of phosphor, usually red and green, are coated onto the inside of the CRT screen, and 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.

Beam penetration has been an inexpensive way to produce color in random-scan monitors, but only four colors are possible, and the quality of pictures is not as good as with other methods.

Shadow Mask Method

Shadow-mask methods are commonly used in raster-scan systems (including 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. Figure (6) illustrates the delta-delta shadow-mask method, commonly used in color CRT- systems.

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.

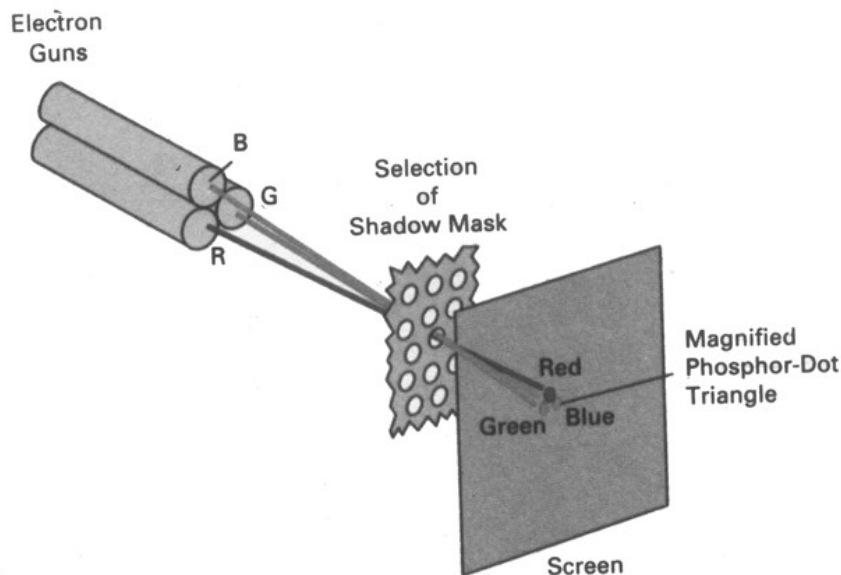


Figure 6: Operation of a delta-delta, shadow-mask CRT.

4. Direct-View Storage Tubes (DVST)

This is an alternative method to monitor a screen image, as it stores 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.

One, the primary gun, is used to store the picture pattern; the second, the flood gun, maintains the picture display.

A DVST monitor has both disadvantages and advantages compared to the refresh CRT. Because no refreshing is needed, very complex pictures can be displayed at very high resolutions without flicker.

Disadvantages of DVST systems are that they ordinarily do not display color and that selected parts of a picture cannot be erased. To eliminate a picture section, the entire screen must be erased and the modified picture redrawn. The erasing and redrawing process can take several seconds for a complex picture. For these reasons, storage displays have been largely replaced by raster systems.

5. Flat-Panel Displays

The term flat panel display refers to a class of video device that have reduced volume, weight and power requirement compared to a CRT.

A significant feature of flat-panel displays is that they are thinner than CRTs, and we can hang them on walls or wear them on our wrists.

Current uses for flat-panel displays include small TV monitors, calculators, pocket video games, laptop computers, armrest viewing of movies on airlines, as advertisement boards in elevators, and as graphics displays in applications requiring rugged, portable monitors.

We can separate flat-panel displays into two categories: emissive displays and non emissive displays.

The emissive displays (or emitters) are devices that convert electrical energy into light. Plasma panels, thin-film electroluminescent displays, and- light-emitting diodes are examples of emissive displays.

Non emissive displays (or non emitters) use optical effects to convert sunlight or light from some other source into graphics patterns. The most important example of a non emissive flat-panel display is a liquid-crystal device.

Plasma panels

- also called 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 ribbons is placed on one glass panel, and set of horizontal ribbons in to other glass panels
- A voltage is applied to these conductors to break down in to a glowing plasma of voltages

Figure Refer text page no 66

Thin film electro luminescent displays

- Similar to the construction of plasma panel
- Difference is the region between glass plate is filled with a phosphor instead of gas
- When high voltage is applied, phosphor emits light

Figure refer text- page no 67

Light-emitting Diode (LED)

In LED, a matrix of diodes is arranged to form the pixel positions in the display and 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)

Liquid crystal displays are the devices that produce a picture by passing polarized light from the surroundings or from an internal light source through a liquid crystal material that transmit the light.

Liquid-crystal displays (LCDs) are commonly used in small systems, such ' as calculators and portable, laptop computers.

These non-emissive devices 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.

The term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid. Flat-panel displays commonly use threadlike liquid-crystal compounds that tend to keep the long axes of the rod-shaped molecules aligned.

A flat-panel display can then be constructed with a nematic liquid crystal, as demonstrated in Fig.(7) . 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" of Fig. 7. Polarized light passing through the material is twisted so that it will pass through the opposite polarizer. The light 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 the light is not twisted.

Picture definitions are stored in a refresh buffer, and the screen is refreshed at the rate of 60 frames per second, as in the emissive devices.

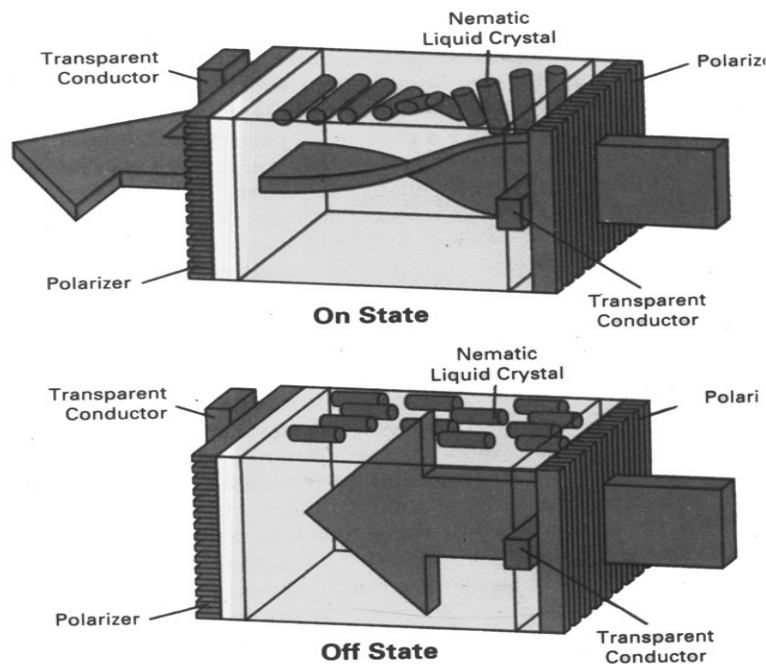


Figure7 : The light-twisting, shutter effect used in the design of most liquid-crystal display devices

6. Three Dimensional Viewing Devices

- Graphics monitors for the display of three-dimensional scenes have been devised using a technique that reflects a CRT image from vibration, flexible mirror.
- As varifocal mirror vibrates, it changes focal length
- These vibrations are synchronized with the display of an object on a CRT so that each point on the object is reflected from the mirror into a special position corresponding to the distance of the point from a specified viewing location. This allows us to walk around an object and view it from different sides.

Figure refer text- page no 69

7. Stereoscopic and Virtual-Reality Systems

- Another technique for the display of 3D scenes.
- Not true 3D images, but provides a 3D effect.

Uses two views of a scene along the lines of right and left eye. Gives perception of a scene depth when right view is seen from right eye and left scene is seen from left eye (stereoscopic effect). Display each view at alternate refresh cycles

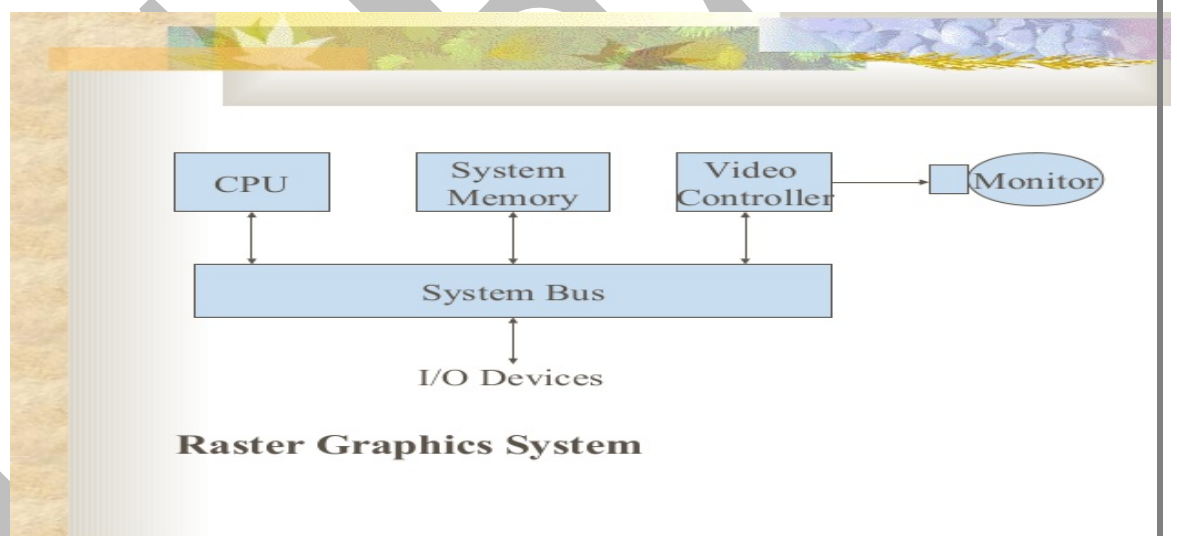
- Stereoscopic systems are used in virtual reality systems:

- Augmented reality
- Immersive reality
- Headset generates stereoscopic views
- Input devices (gloves, helmet, ...) capture motion
- Sensing system in headset tracks user's position
- Scene projected on an arrangement of walls

Raster Scan Systems

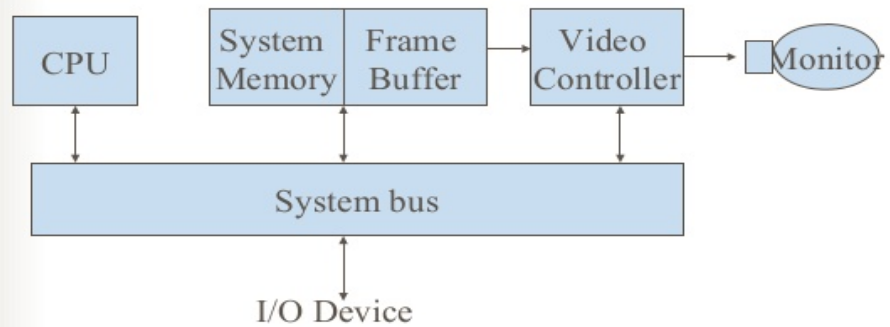
Interactive raster-graphics systems typically employ several processing units. In addition to the CPU, a special purpose processor called the video controller or display controller is used to control the operation of the display device.

The figure shows the organization of a raster system. The frame buffer can be anywhere in the system memory, and the video controller access the frame buffer to refresh the screen.



Architecture of raster system with a fixed portion of the system memory reserved for the frame buffer

Fixed Portion of the system memory is reserved.
Frame buffer locations, and the corresponding screen
Positions are referenced in Cartesian Coordinates.

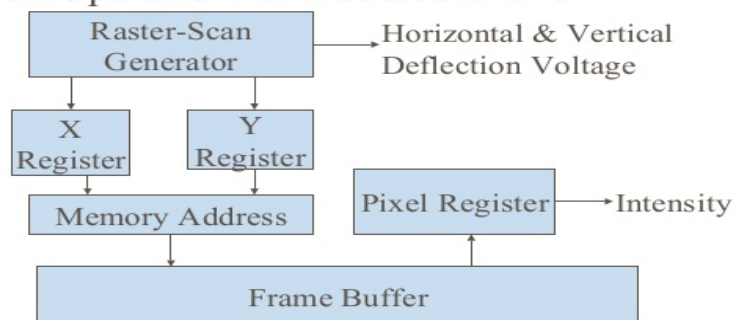


Video Controller

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.

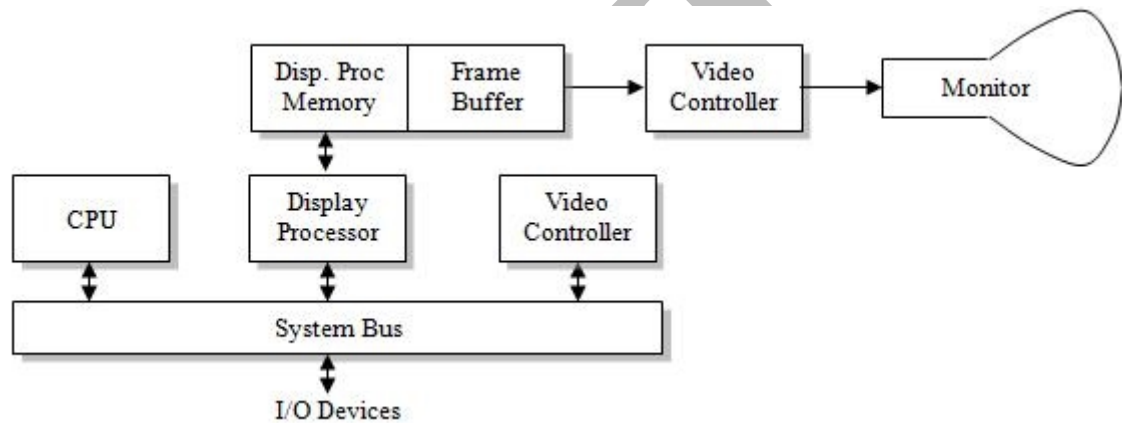
The co-ordinates of the graphics monitor starts at the lower left screen corner. Positive x values increasing to the right and y values increasing from bottom to top.

Refresh Operation in Video controller



The above diagram shows the refresh operation of video controller. Two registers are used to store the co-ordinates of the screen pixels. Initially $x=0$ and $y=y_{\max}$. The value stored in the frame buffer corresponding to this pixel position is retrieved. And the x value is incremented by 1 and the corresponding y value is retrieved, like that the pixel values are retrieved line by line. Once the last pixel is reached again the registers are reset to initial value to repeat the process.

Raster scan Display Processor



Architecture of a raster graphics system with a display processor

- The purpose of the display processor or graphics controller 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.

- A major task of the display processor 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. Lines and other geometric objects are converted into set of discrete intensity points. Characters can be defined with rectangular grids, or they can be defined with curved outlines.

- To reduce the memory space required to store the image information, each scan line are stored as a set of integer pairs.

- One number of each pair indicates an intensity value, and the second number specifies number of adjacent pixels the scan line that is also having same intensity. This technique is called run-length encoding.

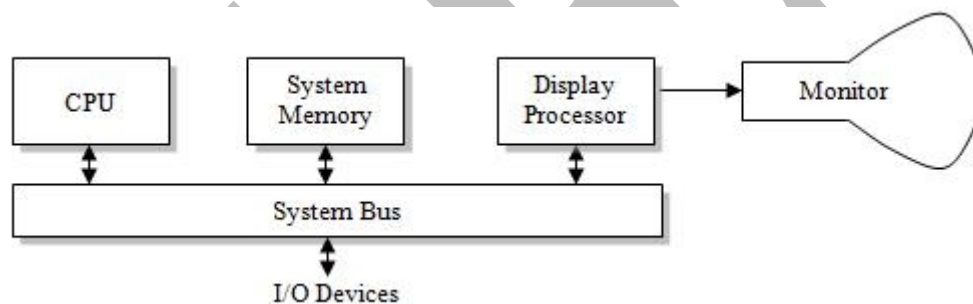
Random-scan Systems:

An application program is input and stored in the system memory along with a graphics package. Graphics commands in the 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 refreshed to as a display processing unit or a graphics controller.

Graphical 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 co-ordinate endpoints, and these input co-ordinate 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.



Difference between Raster scan and Random scan systems

Base of Difference	Raster Scan System	Random Scan System
Electron Beam	The electron beam is swept across the screen, one row at a time, from top to bottom.	The electron beam is directed only to the parts of screen where a picture is to be drawn.

Resolution	Its resolution is poor because raster system in contrast produces zig-zag lines that are plotted as discrete point sets.	Its resolution is good because this system produces smooth lines drawings because CRT beam directly follows the line path.
Picture Definition	Picture definition is stored as a set of intensity values for all screen points, called pixels in a refresh buffer area.	Picture definition is stored as a set of line drawing instructions in a display file.
Realistic display	The capability of this system to store intensity values for pixel makes it well suited for the realistic display of scenes contain shadow and color pattern.	These systems are designed for line-drawing and can't display realistic shaded scenes.
Draw an Image	Screen points/pixels are used to draw an image.	Mathematical functions are used to draw an image.

Graphic

Various input Devices

Various devices are available for data input on graphics workstations. Most systems have a keyboard and one or more additional devices specially designed for interactive input.

Keyboards

An alphanumeric keyboard on a graphics system is used primarily as a device for entering text strings. The keyboard is an efficient device for inputting such non-graphic data as picture labels associated with a graphics display. Keyboards can also be provided with features to facilitate entry of screen co-ordinates, menu selections or graphics functions.

Cursor-control keys and functions keys are common features of general purpose keyboards. Function keys allow users to enter frequently used operations in

a single keystroke, and cursor control keys can be used to select display objects or co-ordinate positioning devices. Additionally, a numeric keyboard is often included on the keyboard, for fast entry of numeric data.

Mouse

A mouse is a small hand-held device used to position the screen cursor. Wheels or rollers on the bottom of the mouse can be used to record the amount and direction of movement. Another method of detecting mouse motion is with an optical sensor. One, two or three buttons are usually included on top of the mouse for signaling the execution of some operation.

The Z-mouse includes three buttons, a thumbwheel on the side, a trackball on the top, and a standard mouse ball underneath. This design provides six degrees of freedom to select the object and to perform the actions.

Trackball & Spaceball

As the name implies, a trackball is a ball that can be rotated with the finger or palm of the hand, to produce screen-cursor movement. Potentiometers attached to the ball, measure the amount and direction of rotation. Track balls are often mounted on keyboards.

While a trackball is a two-dimensional positioning device, a Spaceball provides six degrees of freedom. The Spaceball does not move. Strain gauges measure the amount of pressure applied to the Spaceball to provide input for spatial positioning and orientation as the ball is pushed or pulled in various directions. Spaceballs are used for 3D positioning and selection generations in virtual reality systems.

Joysticks

A joystick consists of a small, vertical lever (called the stick) mounted on a base that is used to steer the screen cursor around. The distance that the stick is moved in any direction from its center position corresponds to screen-cursor movement in that direction.

Potentiometers mounted at the base of the joystick measure the amount of the movement, and springs return the stick to the centre position when it is released. One or more buttons can be programmed to act as input switches.

Data Glove

Data glove can be used to grasp a “virtual” object. The glove is constructed with a series of sensors that detect hand and finger motions. Electromagnetic coupling between transmitting antennas and receiving antennas is used to provide information about the position and orientation of the hand. Input from a glove can be used to position or manipulate objects in a virtual scene.

Digitizers

A common device for drawing, partitioning or interactively selecting co-ordinates positions on an object is digitizer. These devices can be used to input co-ordinate values in either a 2D or 3D space.

One type of digitizer is the graphics tablet which is used to input 2D co-ordinates by activating a hand cursor at selected positions on a flat surface. A hand cursor contains cross hairs for sighting positions, while a stylus is a pencil shaped device that is pointed at positions on the tablet.

Many graphics tablets are constructed with a rectangular grid of wires embedded in the tablet surface. Electromagnetic pulses are generated in sequence along the wires, and an electric signal is induced in a wire coil in an activated stylus or hand cursor to record a tablet position.

Acoustic (or Sonic) tablets use sound waves to detect the stylus position. 3D digitizers use sonic or electromagnetic transmissions to record positions.

Image Scanners

Drawings, graph, photos or text can be stored for computer processing with an image scanner by passing an optical scanning mechanism over the information to be stored. The objects are stored in an array, these representations of a picture, can be transformed like rotation, scaling and enhancements.

Touch Panels

It allows displayed objects or screen positions to be selected with the touch of a finger. Touch input can be recorded using optical, electrical or acoustical methods.

Optical touch panels employ a line of infrared Light-Emitting Diodes (LED) along one vertical edge and along one horizontal edge of the frame. The opposite vertical and horizontal edges contain light detectors. These detectors are used to record which beams are interpreted when the panel is touched. The two crossing beams that are interpreted identify the horizontal and vertical co-ordinates of the screen position selected.

Light Pens

Light pens are pencil shaped devices are used to select screen positions by detecting the light coming from points on the CRT screen. They are sensitive to short burst of light emitted from the phosphor coating; at the instant the electron beam strikes a particular point. Other light sources are not usually detected by a light pen.

An activated light pen, pointed at a spot on the screen as the electron beam lights up the spot, generates an electrical pulse that causes the co-ordinate position of the electron beam to be recorded. As with cursor-positioning devices, recorded light pen co-ordinates can be used to position an object or to select a procession option.

Voice Systems

Speech recognizers are used in some graphics workstations as input devices to accept voice commands. The voice-system input can be used to initialize graphics operations to enter data. These systems operate by matching an input against a predefined dictionary of words and phrases. A dictionary is setup for the operator; each word is spoken several times and stored. When a voice command is given, the system searches the dictionary for a match.

Hard-Copy Devices

The graphics can be obtained as hard-copy output in several formats. The images can be converted as 35-mm slides, photographs or it can be taken as output

by a printer or plotter. The quality of the pictures obtained from a device depends on dot size and the number of dots per inch (dpi), or lines per inch (lpi), that can be displayed.

Printers produce output by either impact or non-impact methods. Impact printers' press formed character faces against an inked ribbon onto the paper. A line printer is an example of an impact device, with the typefaces mounted on bands, chains, drums, or wheels.

Non-impact printers and plotters use laser techniques to get images onto paper.

Character impact printers often have a dot-matrix print head containing a rectangular array of protruding wire pins, with the number of pins depending on the quality of the printer. Individual characters or graphics patterns are obtained by retracting certain pins so that the remaining pins from the pattern to be printed.

In a laser device, a laser beam creates a charge distribution on a rotating drum coated with photoelectrical methods such as selenium. Toner is applied to the drum and then transformed to paper.

Ink-jet methods produce output by squirting ink in horizontal rows across a roll of paper wrapped on a drum. The electrically charged ink stream is deflected by an electric field to produce dot-matrix patterns.

We can get limited color output on an impact printer by using different colored ribbons. Non-impact printers use various techniques to combine three color pigments (cyan, magenta and yellow) to produce a range of color patterns. Laser and xerographic devices deposit the three pigments on separate passes; ink-jet methods shoot the three colors simultaneously on a single pass along each print line on the paper.

Drafting layouts and other drawings are typically generated with ink-jet or pen plotters. A pen plotter has one or more pens mounted on a carriage, or crossbar, that spans a sheet of paper. Pens with varying colors and widths are used to produce a variety of shadings and line style. Plotter paper can lie flat or be rolled onto a drum or belt. Either, clamps, a vacuum, or an electrostatic charge hold the paper in position.

Printers

A printer is an output device that produces a *hard copy* of data. The resolution of printer output is expressed as [DPI](#). Printers can be classified into different types in several ways. First, the printers can be divided into three categories by the way they print.

- **Impact Printers:** Hammer hits ribbons, papers or print head. Dot-matrix and daisy-wheel printers are the example. Noisy.
- **Nonimpact Printers:** They do not have the hammer and do not hit. An example is an ink-jet and laser printer.

Another classification can be made by the way they form characters.

- **Bit-Mapped Printers:** Images are formed from groups of dots and can be placed anywhere on the page. They have many printing options and good printing quality. They use *PostScript* as a standard language for instructing a microcomputer.
- **Character-based Printers:** Printer print characters into the lines and columns of a page. These printers use predefined set of characters and are restricted in position of characters.

Microcomputers use five kinds of printers. They are daisy wheel printers, chain printers, dot-matrix printers, ink-jet printers, and laser printers.

Daisy-Wheel Printer

Daisy-Wheel is a printer mechanism that uses any kind of hub (wheel) having a set of spokes at the margin of the hub. The wheel can be removed to use a different character set. The end of each spoke is a raised image of a type character. When the wheel is turned and the required character is aligned to the print hammer, the character is then struck into a ribbon and onto a paper with the hammer.

Daisy-Wheel Printer prints typewriter-like very high quality characters. However, they are slower and less reliable than dot-matrix printers. Microcomputer users seldom use this printer, because the better dot-matrix printers and inexpensive laser printers are available today.

Chain Printer

A *chain printer* uses a printing mechanism that uses character typefaces linked together in a chain. The chain spins horizontally around a set of hammers aligned with each position. When the required character is in front of the selected

print position, hammer in that position hits the paper into the ribbon against the character in the chain.

This printer is not commonly found around microcomputers, because it is a very expensive, high-speed machine designed originally for mainframes and minicomputers. Chain printers are very reliable and can speed up to 3000 lines per minute.

Dot-Matrix Printer

Dot-matrix printers are printers that write characters and form graphic images using one or two columns of tiny dots on a print head. The dot hammer moving serially across the paper strikes an inked-ribbon and creates images on paper.

Dot matrix printers are popular printers used with microcomputers, because the printers are highly reliable and inexpensive. They are used for tasks where a high-quality image is not essential. Many users, however, move from dot printers to laser printers, because the price of laser printers is falling down. Several kinds of dot matrix printers are available with print heads that have 7, 9, 18, or 24 pins.

Ink-Jet Printer

Ink-jet is a printer mechanism that sprays one or more color of ink at high speed onto the paper and produces high-quality printing. This printer also produces color printing as well as high-quality image. That is, ink-jet printers can be used for variety of color printing at a relatively low cost. Ink-jet printing has two methods: Continuous stream method and drop-on- demand method.

Laser Printer

A *laser printer* is a printer that uses the electrophotographic method used in a copy machine. The printer uses a laser beam light source to create images on a photographic drum. Then the images on the drum are treated with a magnetically charged toner and then are transferred onto a paper. A heat source is usually applied to make the images adhere. In 1984, Hewlett-Packard introduced the first desktop laser printer, called the LaserJet. The laser printer revolutionized personal computer printing and has spawned desktop publishing. The laser printer produces high-

resolution letters and graphics quality images, so it is adopted in applications requiring high-quality output. Although a high-priced color laser printer is also available in the market, a less expensive, desktop gray scale laser printer is widely used. Recently, the laser printer is gaining its market share dramatically, mainly because the lowered price and the quality.

Plotters

A *plotter* is a special-purpose output device that draws images with ink pens. That is, the plotter is a graphics printer for making sophisticated graphs, charts, maps, and three-dimensional graphics as well as high-quality colored documents. It can also produce larger size of documents. Plotters require data in a vector graphics format that can produce images with a series of lines. There are two main types of plotters:

- **Drum Plotter:** This is a plotter that has a drum. A paper wraps the drum that rotates to produce plots. Pens in a drum plotter move across the paper while the drum is turning. A drum plotter is usually used to produce smaller drawings.
- **Flatbed Plotter:** This is a plotter that has a bed. This is also called a *table plotter*. The plotter draws graphics on the paper placed on the bed. There are several size of beds. This plotter is usually used for producing large drawings.

Physical Interactive Devices

Tablets

Touch Panels

Control Dials

Joystick

Trackball

Mouse

Function Switches

Light Pen

Spaceball

Data generation Devices-

$$\tilde{r}(u) = \sum_{i=0}^m$$

where

Scanners and Three dimensional digitizers

ACCEPTED