COMPUTER GRAPHICS

UNIT I

Introduction, Overview of Graphics Systems, Video Display Devices, Refresh Cathode Ray Tubes, Raster Scan and Random Scan Displays, Raster Scan and Random Scan Display Processor, Color CRT Monitors, DBST, 3D Viewing Devices, Stereoscopic and VR Systems, Input Devices, Hard Copy Devices.

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. Here in our lab at the Program of Computer Graphics, we think of computer graphics as drawing pictures on computers, also called 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. We spend much of our time improving the way computer pictures can simulate real world scenes. We want images on computers to not just look more realistic, but also to be more realistic in their colors, the way objects and rooms are lighted, and the way different materials appear. We call this work ―realistic image synthesis‖.

Interactive Graphics

In interactive computer graphics user have some control over the picture i.e user can make any change in the produced image. One example of it is the ping pong game. The conceptual model of any interactive graphics system is given in the picture shown in Figure

At the hardware level (*not shown in picture*), a computer receives input from interaction devices, and outputs images to a display device. The software has three components. The first is the application program, it creates, stores into, and retrieves from the second component, the application model, which represents the the graphic primitive to be shown on the screen. The application program also handles user input. It produces views by sending to the third component, the graphics system, a series of graphics output commands that contain both a detailed geometric description of what is to be viewed and the attributes describing how the objects should appear. After the user input is processed, it sent to the graphics system is for actually producing the picture. Thus the graphics system is a layer in between the application program and the display hardware that effects an output transformation from objects in the application model to a view of the model.

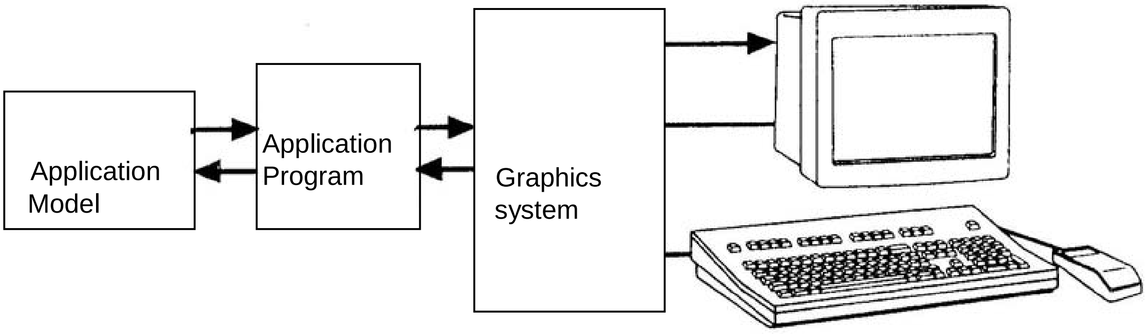


Figure 1.1: Conceptual model for interactive graphics

The objective of the application model is to captures all the data, objects, and relationships among them that are relevant to the display and interaction part of the application program and to any nongraphical postprocessing modules.

Passive Graphics

A computer graphics operation that transfers automatically and without operator intervention. Non-interactive computer graphics involves one way communication between the computer and the user. Picture is produced on the monitor and the user does not have any control over the produced picture.

Advantages of Interactive Graphics

Graphics provides one of the most natural means of communicating with a computer, since our highly developed 2D and 3D pattern-recognition abilities allow us to perceive and process pictorial data rapidly and efficiently. In Many design, implementation, and construction processes today, the information pictures can give is virtually indispensable. Scientific visualization became an important field in the late 1980s, when scientists and engineers realized that they could not interpret the data and prodigious quantities of data produced in supercomputer runs without summarizing the data and highlighting trends and phenomena in various kinds of graphical representations.

Creating and reproducing pictures, however, presented technical problems that stood in the way of their widespread use. Thus, the ancient Chinese proverb ―a picture is worth ten thousand words‖ became a cliché in our society only after the advent of inexpensive and simple technology for producing pictures—first the printing press, then photography.

Interactive computer graphics is the most important means of producing pictures since the invention of photography and television; it has the added advantage that, with the computer, we can make pictures not only of concrete, ―real-world‖ objects but also of abstract, synthetic objects, such as mathematical surfaces in 4D and of data that have no inherent geometry, such as survey results. Furthermore, we are not confined to static images. Although static pictures are a good means of communicating information, dynamically varying pictures are frequently even better–to time-varying phenomena, both real (e.g., growth trends, such as nuclear energy use in the United States or population movement form cities to suburbs and back to the cities). Thus, a movie can show changes over time more graphically than can a sequence of slides. Thus, a sequence of frames displayed on a screen at more than 15 frames per second can convey smooth motion or changing form better than can a jerky sequence, with several seconds between individual frames. The use of dynamics is especially effective when the user can control the animation by adjusting the speed, the portion of the total scene in view, the amount of detail shown, the geometric relationship of the objects in the another, and so on. Much of interactive graphics technology therefore contains hardware and software for user-controlled motion dynamics and update dynamics.

With motion dynamics, objects can be moved and tumbled with respect to a stationary observer. The objects can also remain stationary and the viewer can move around them , pan to select the portion in view, and zoom in or out for more or less detail, as though looking through the viewfinder of a rapidly moving video camera. In many cases, both the objects and the camera are moving. A typical example is the flight simulator, which combines a mechanical platform supporting a mock cockpit with display screens for windows. Computers control platform motion, gauges, and the simulated world of both stationary and moving objects through which the pilot navigates.

Update dynamics is the actual change of the shape, color, or other properties of the objects being viewed.. With the recent development of digital signal processing (DSP) and audio synthesis chips, audio feedback can now be provided to augment the graphical feedback and to make the simulated environment even more realistic.

Interactive computer graphics thus permits extensive, high-bandwidth user-computer interaction. This significantly enhances our ability to understand data, to perceive trends, and to visualize real or imaginary objects–indeed, to create ―virtual worlds‖ that we can explore from arbitrary points of view. By making communication more efficient, graphics make possible higher-quality and more precise results or products, greater productivity, and lower analysis and design costs.

How the Interactive Graphics Display Works

The modern graphic display is very simple in construction. It consists of the three components shown in figure 1.2 below.

(1) Frame Buffer

(2) Monitor like a TV set without the tuning and receiving electronics.

(3) Display Controller It passes the contents of the frame buffer to the monitor.

Scan line Data (Frame Buffer)

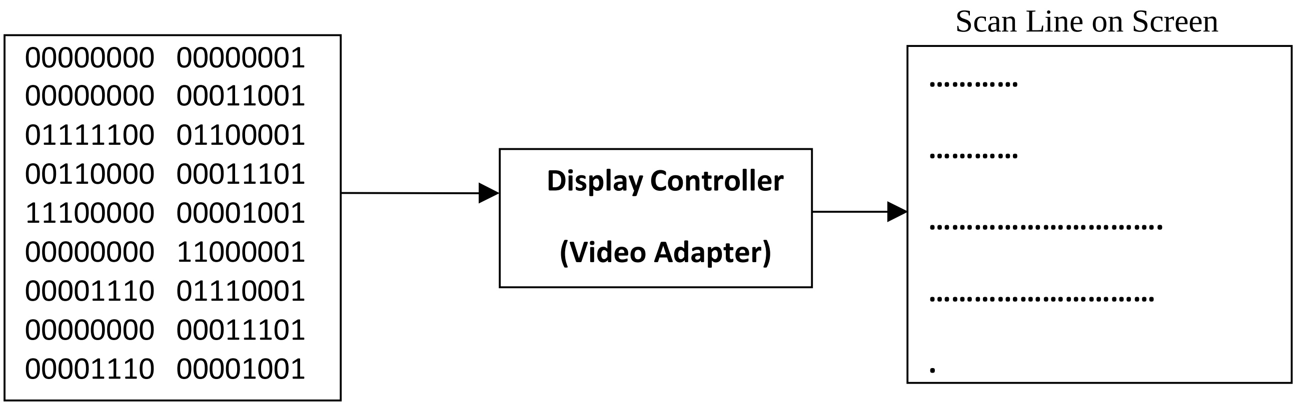


Figure 1.2

Inside the frame buffer the image is stored as a pattern of binary digital numbers, which represent a array of picture elements, or pixels. In the simplest case, where you want to store only black and white images, you can represent black pixels by —1‘s‖ and white pixels by —0‘s‖ in the frame buffer. Therefore, a array of black and white pixels of 16X16 could be represented by 32 bytes, stored in frame buffer.

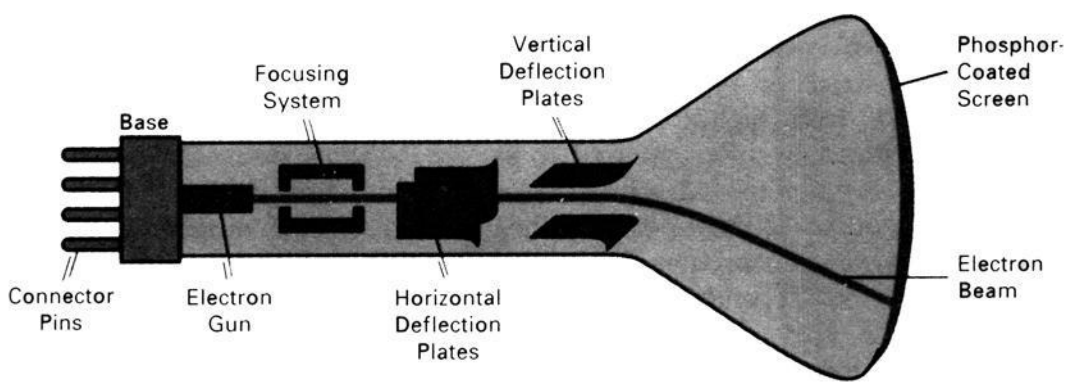
The display controller reads each successive byte of data from the frame buffer and converts its 0‘s and 1‘s into corresponding video signals. This signal is then fed to the monitor, producing a black and white image on the screen. The display controller repeats this operation 30 times a second to maintain a steady picture on the monitor. If you want to change the image, then you need to modify the frame buffer‘s contexts to represent the new pattern of pixels.

Display Devices

The principle of producing images as collections of discrete points set to appropriate colours is now widespread throughout all fields of image production. 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.

Basic Operation of 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. 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. 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. 2.2). 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 in- side of the CRT envelope near the phosphor screen, or an accelerating anode can be used, as in Fig. 2.2. Sometimes the electron gun is built to contain the accelerating anode and focusing system within the same unit.



The focusing system in a CRT is needed to 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 either electric or magnetic fields. Electrostatic focusing is commonly used in television and computer graphics monitors. With electrostatic focusing, the electron beam passes through a positively charged metal cylinder that forms an electrostatic lens, as shown in Fig. 2.3. Similar lens focusing effects can be accomplished with a magnetic field set up by a coil mounted around the outside of the CRT envelope. Magnetic lens focusing produces the smallest spot size on the screen and is used in special-purpose devices.

The CRT envelope, as illustrated in Fig. 2.1. 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. Spots of light are produced on the screen by the transfer of the CRT beam energy to the phosphor. When the electrons in the beam collide with the phosphor coating, they are stopped and their kinetic energy is absorbed by the phophor. 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 quanturn-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 quantums of light energy. What we see on the screen is the combined effect of all the electron light emissions: a glowing spot that quickly fades after all the excited phosphor electrons have returned to their ground energy level. The frequency (or color) of the light emitted by the phosphor is proportional to the energy difference between the excited quantum state and the ground state.

Figure 2.4 shows the intensity distribution of a spot on the screen. The intensity is greatest at the center of the spot, and decreases with a Gaussian distribution out to the edges of the spot. This distribution corresponds to the cross-sectional electron density distribution of the CRT beam.

Figure 2.4: Intensity distribution of an illuminated phosphor spot on a CRT screen

Resolution

The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution. A more precise definition of resolution is the number of points per centimeter that can be plotted horizontally and vertically, although it is often simply stated as the total number of points in each direction. This depends on the type of phosphor used and the focusing and deflection system.

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.

Random-Scan and Raster Scan Monitor

Random-Scan/Calligraphic displays

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. When operated as a random-scan display unit, a CRT has the electron beam 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 and for this reason are also referred to as vector displays (or stroke- writing or calligraphic displays) Fig. 2.5. A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.

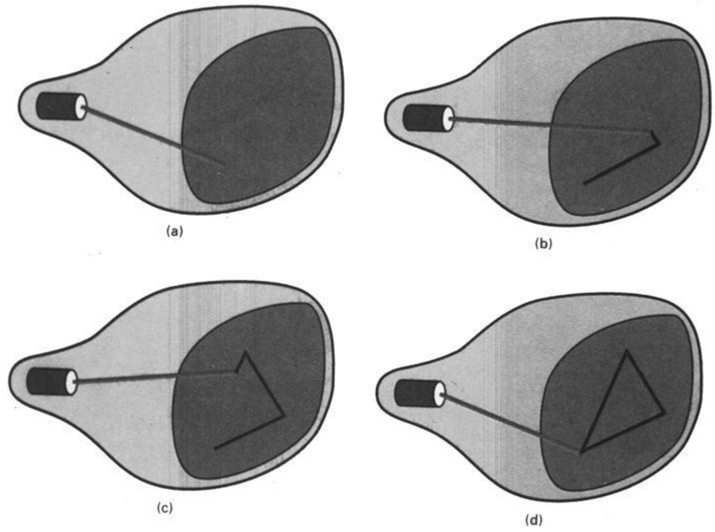


Figure 2.5: A random-scan system draws the component lines of an object in any order specified

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 can-not 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. The matrix of pixels constitutes the raster. The number of separate pixels in the raster display might typically range from 256X256 to 1024X 1024. Each pixel on the screen can be made to glow with a different brightness. Colour screen provide for the pixels to have different colours 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. 2.6). 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.

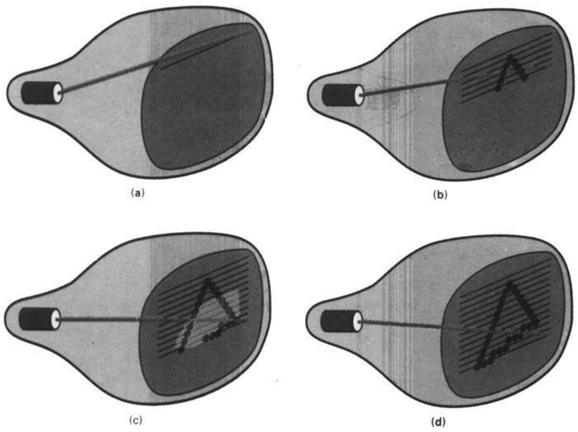
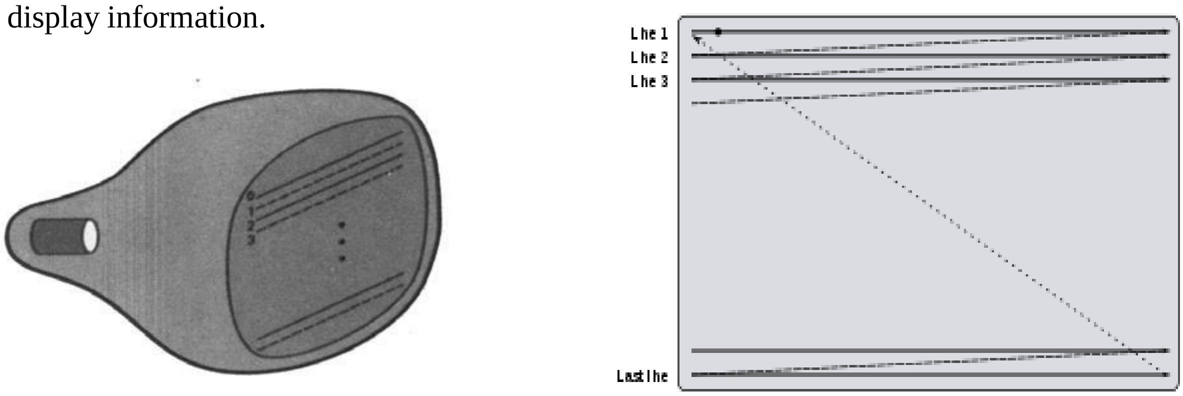


Figure 2.6: A raster-scan system displays an object as a set of discrete points across each scan line

Intensity range for pixel positions depends on the capability of the raster system. 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. Interlacing of the scan lines in this way allows us to see the entire screen displayed in one-half the time it would have taken to sweep across all the lines at once from top to bottom. Interlacing is primarily used with slower refreshing rates. On an older, 30 frame- per-second, noninterlaced display, for instance, some flicker is noticeable. But with interlacing, each of the two passes can be accomplished in l/60th of a second, which brings the refresh rate nearer to 60 frames per second. This is an effective technique for avoiding flicker, providing that adjacent scan lines contain similar display information.



The above figure Interlacing Scan lines on a raster-scan display. First , all points on the even-numbered (solid) scan lines are displayed; then all points along the odd- numbered (dashed) lines are displayed

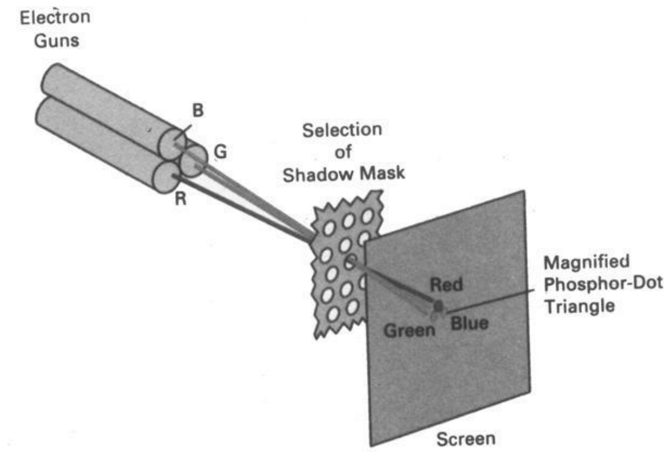
Color CRT Monitors

To display colour pictures, combination of phosphorus is used that emits different coloured light. There are two different techniques for producing colour displays with a CRT. Beam Penetration Method

Shadow Mask Method (or) 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



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. 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. Three electron guns, aligned with the triangular color-dot patterns on the screen, are directed to each dot triangle by a shadow mask.

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.

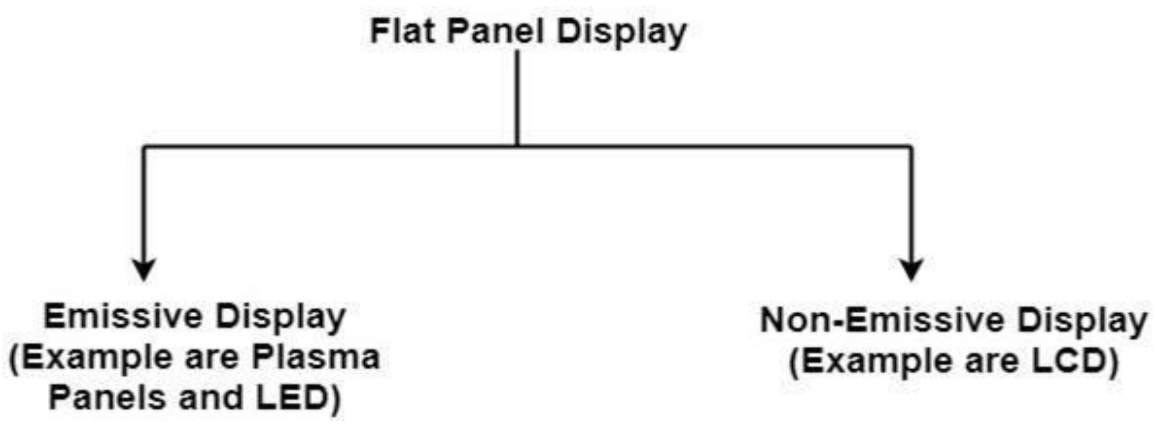
Direct-View Storage Tubes (DVST)

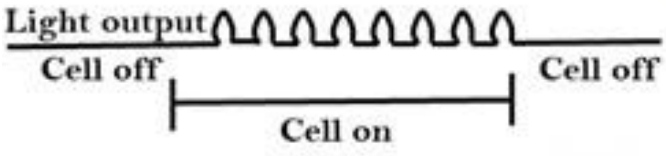
This is an alternative method to monitor a screen image, as it sores the picture information inside the CRT instead of refreshing the screen. A direct-view storage tube (DVST) stores the picture information as a charge distribution just behind the phosphor-coated screen. Two electron guns are used in 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.

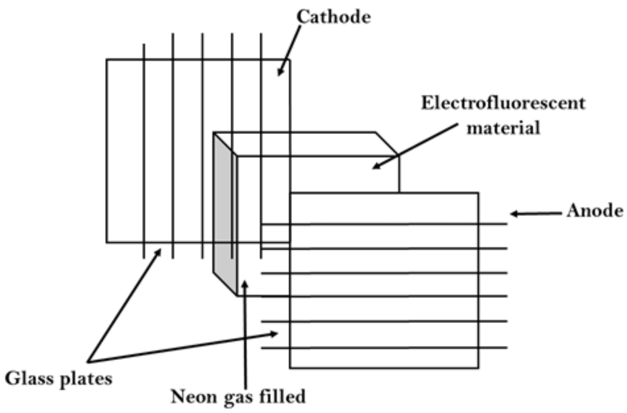
Flat Panel Display:

The Flat-Panel display refers to a class of video devices that have reduced volume, weight and power requirement compare to CRT.

Example: Small T.V. monitor, calculator, pocket video games, laptop computers, an advertisement board in elevator.







1. Emissive Display: The emissive displays are devices that convert electrical energy into light. Examples are Plasma Panel, thin film electroluminescent display and LED (Light Emitting Diodes).

2. Non-Emissive Display: The Non-Emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. Examples are LCD (Liquid Crystal Device).

Plasma Panel Display:

Plasma-Panels are also called as Gas-Discharge Display. It consists of an array of small lights. Lights are fluorescent in nature. The essential components of the plasma-panel display are:

1. **Cathode:** It consists of fine wires. It delivers negative voltage to gas cells. The voltage is released along with the negative axis.
2. **Anode:** It also consists of line wires. It delivers positive voltage. The voltage is supplied along positive axis.
3. **Fluorescent cells:** It consists of small pockets of gas liquids when the voltage is applied to this liquid (neon gas) it emits light.
4. **Glass Plates:** These plates act as capacitors. The voltage will be applied, the cell will glow continuously.

The gas will slow when there is a significant voltage difference between horizontal and vertical wires. The voltage level is kept between 90 volts to 120 volts. Plasma level does not require refreshing. Erasing is done by reducing the voltage to 90 volts.

Each cell of plasma has two states, so cell is said to be stable. Displayable point in plasma panel is made by the crossing of the horizontal and vertical grid. The resolution of the plasma panel can be up to 512 * 512 pixels.

Advantage:

1. High Resolution
2. Large screen size is also possible.
3. Less Volume
4. Less weight
5. Flicker Free Display

Disadvantage:

1. Poor Resolution
2. Wiring requirement anode and the cathode is complex.
3. Its addressing is also complex.

LED (Light Emitting Diode):

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

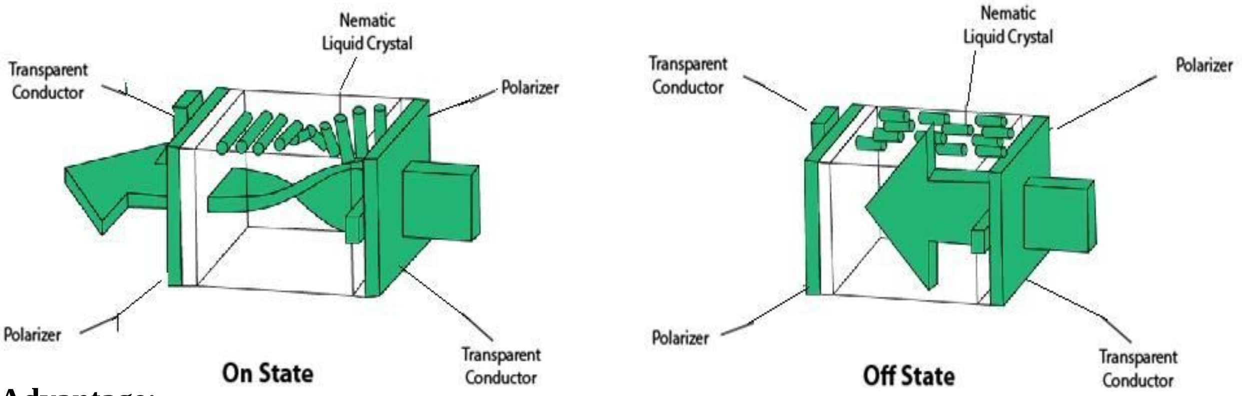
LCD (Liquid Crystal Display):

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 transmits the light.

LCD uses the liquid-crystal material between two glass plates; each plate is the right angle to each other between plates liquid is filled. One glass plate consists of rows of conductors arranged in vertical direction. Another glass plate is consisting of a row of conductors arranged in horizontal direction. The pixel position is determined by the intersection of the vertical & horizontal conductor.

This position is an active part of the screen.

Liquid crystal display is temperature dependent. It is between zero to seventy degree Celsius. It is flat and requires very little power to operate.



Advantage:

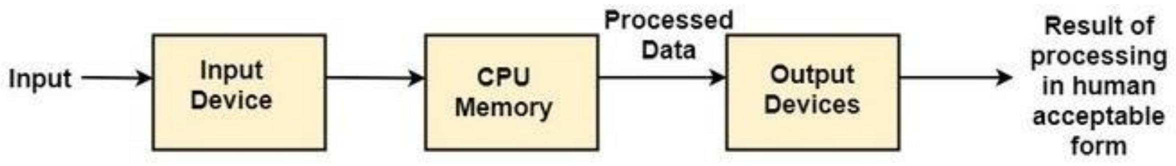
Low power consumption.
Small Size
Low Cost

Disadvantage:

LCDs are temperature-dependent (0-70°C)
LCDs do not emit light; as a result, the image has very little contrast.
LCDs have no color capability.
The resolution is not as good as that of a CRT.

Input Devices

The Input Devices are the hardware that is used to transfer transfers input to the computer. The data can be in the form of text, graphics, sound, and text. Output device display data from the memory of the computer. Output can be text, numeric data, line, polygon, and other objects.



These Devices include:

1. **Keyboard**
2. **Mouse**
3. **Trackball**
4. **Spaceball**
5. **Joystick**
6. **Light Pen**
7. **Digitizer**
8. **Touch Panels**
9. **Voice Recognition**
10. **Image Scanner**

Keyboard:

The most commonly used input device is a keyboard. The data is entered by pressing the set of keys. All keys are labeled. A keyboard with 101 keys is called a QWERTY keyboard. The keyboard has alphabetic as well as numeric keys. Some special keys are also available.

1. **Numeric Keys:** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
2. **Alphabetic keys:** a to z (lower case), A to Z (upper case)
3. **Special Control keys:** Ctrl, Shift, Alt
4. **Special Symbol Keys:** ; , " ? @ ~ ? :
5. **Cursor Control Keys:** ↑ → ← ↓
6. **Function Keys:** F1 F2 F3 ... F9.
7. **Numeric Keyboard:** It is on the right-hand side of the keyboard and used for fast entry of numeric data.

Mouse:

A Mouse is a pointing device and used to position the pointer on the screen. It is a small palm size box. There are two or three depression switches on the top. The movement of the mouse along the x-axis helps in the horizontal movement of the cursor and the movement along the y-axis helps in the vertical movement of the cursor on the screen. The mouse cannot be used to enter text. Therefore, they are used in conjunction with a keyboard.

Hard Copy Devices

There are different types and models of printers. The most commonly used computerprinters are

1. Inkjet Pinter
2. Laser Printer
3. Plotters Printer
4. Dot-matrix Printer and
5. Thermal Printer

Inkjet Printer: - Inkjet printers one of the user friendly computer printers. It works by propelling variably-sized droplets of liquid or molten material (ink) onto almost any medium. They are the most common type of printer for the general consumer due to their low cost, high quality of output, capability of printing in glowing color, and easy to use and handle. 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.

Laser Printer: - Laser printer uses LED-technology to obtain small particles of toner from a cartridge onto paper. They produce high quality text and graphics on plain paper. They are generally more economical to use than the ink of inkjet printers. In a laser device, a laser beam creates a charge distribution on a rotating drum coated with a photoelectric material, such as selenium. Toner is applied to the drum and then transferred to paper.

Plotters Printer: - Plotters printer are very different from others printers. Unlike other printer Pen Plotters print by moving a pen across the surface of a piece of paper. Plotters printer is the best way to produce color high-resolution vector-based artwork, or very large drawings efficiently.

Dot-matrix Printer: - This printer is somehow like typewriting. They create characters by striking pins against an ink ribbon. Each pin makes a dot, and combinations of dots form characters and illustrations. The printing involves mechanical pressure, so these printers can create carbon copies and carbonless copies as well.

Thermal Printer: - Thermal printer is an inexpensive printer that works by pushing heated pins against heat-sensitive paper. Thermal printers are generally used in calculators and fax machines.