



UNIT - I
APPLICATIONS OF COMPUTER GRAPHICS

Applications of Computer Graphics:

Computer graphics deals with creation, manipulation and storage of different type of images and objects.

Some of the applications of computer graphics are:

Computer Art:

Using computer graphics we can create fine and commercial art which include animation packages, paint packages. These packages provide facilities for designing object shapes and specifying object motion. Cartoon drawing, paintings, logo design can also be done.

Computer Aided Drawing:

Designing of buildings, automobile, aircraft is done with the help of computer aided drawing, this helps in providing minute details to the drawing and producing more accurate and sharp drawings with better specifications.

Presentation Graphics:

For the preparation of reports or summarizing the financial, statistical, mathematical, scientific, economic data for research reports, managerial reports, moreover creation of bar graphs, pie charts, time chart, can be done using the tools present in computer graphics.

Entertainment:

Computer graphics finds a major part of its utility in the movie industry and game industry. Used for creating motion pictures, music video, television shows, cartoon animation films. In the game industry where focus and interactivity are the key players, computer graphics helps in providing such features in the efficient way.

Education:

Computer generated models are extremely useful for teaching huge number of concepts and fundamentals in an easy to understand and learn manner. Using computer graphics many educational models can be created through which more interest can be generated among the students regarding the subject.

Training:

Specialized system for training like simulators can be used for training the candidates in a way that can be grasped in a short span of time with better understanding. Creation of training modules using computer graphics is simple and very useful.

Graphic operations:

- A general purpose graphics package provides user with Variety of function for creating and manipulating pictures.
- The basic building blocks for pictures are referred to as output primitives. They includes character, string, and geometry entities such as point, straight lines, curved lines, filled areas and shapes defined with arrays of color points.
- Input functions are used for control & process the various input device such as mouse, tablet, etc.



- Control operations are used to controlling and housekeeping tasks such as clearing display screen etc.
- All such inbuilt function which we can use for our purpose are known as graphics function

Software Standard

- Primary goal of standardize graphics software is portability so that it can be used in any hardware systems & avoid rewriting of software program for different system
- Some of these standards are discussed below

Graphical Kernel System (GKS)

- This system was adopted as a first graphics software standard by the international standard organization (ISO) and various national standard organizations including ANSI.
- GKS was originally designed as the two dimensional graphics package and then later extension was developed for three dimensions.

PHIGS (Programmer's Hierarchical Interactive Graphic Standard)

- PHIGS is extension of GKS. Increased capability for object modeling, color specifications, surface rendering, and picture manipulation are provided in PHIGS.
- Extension of PHIGS called "PHIGS+" was developed to provide three dimensional surface shading capabilities not available in PHIGS.

Output primitives

Points and lines

- Point plotting is done by converting a single coordinate position furnished by an application program into appropriate operations for the output device in use.
- Line drawing is done by calculating intermediate positions along the line path between two specified endpoint positions.
- The output device is then directed to fill in those positions between the endpoints with some color.
- For some device such as a pen plotter or random scan display, a straight line can be drawn smoothly from one end point together.
- Digital devices display a straight line segment by plotting discrete points between the two endpoints.
- Discrete coordinate positions along the line path are calculated from the equation of the line.
- For a raster video display, the line intensity is loaded in frame buffer at the corresponding pixel positions.
- Reading from the frame buffer, the video controller then plots the screen pixels.
- Screen locations are referenced with integer values, so plotted positions may only approximate actual line positions between two specified endpoints.
- For example line position of (12.36, 23.87) would be converted to pixel position (12, 24).
- This rounding of coordinate values to integers causes lines to be displayed with a stairstep appearance ("the jaggies"), as represented in fig 2.1.

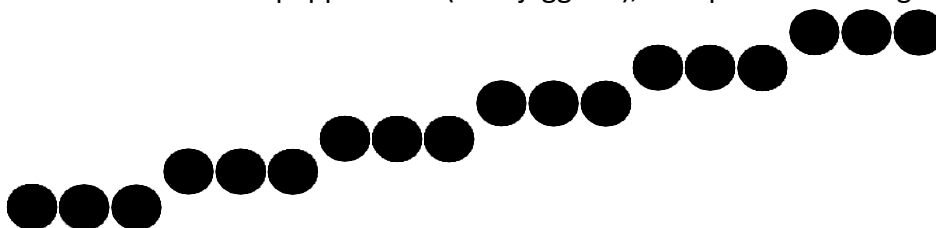
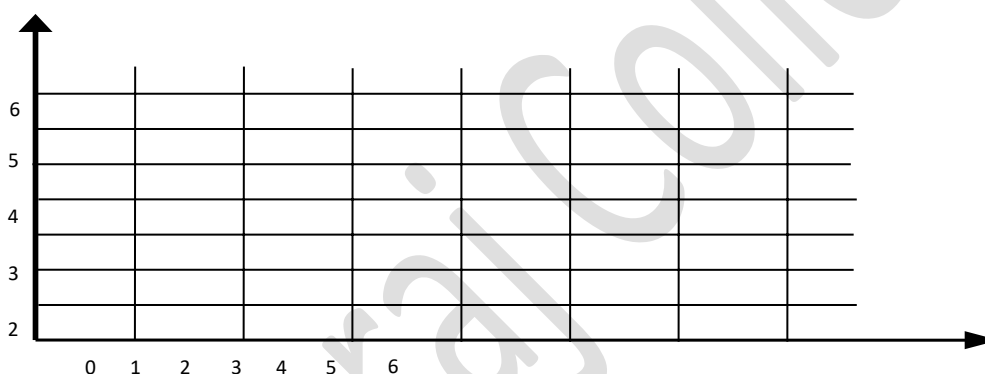




Fig. 2.1: – Stair step effect produced when line is generated as a series of pixel positions.

- The stair step shape is noticeable in low resolution system, and we can improve their appearance somewhat by displaying them on high resolution system.
- More effective techniques for smoothing raster lines are based on adjusting pixel intensities along the line paths.
- For raster graphics device-level algorithms discussed here, object positions are specified directly in integer device coordinates.
- Pixel position will be referenced according to scan-line number and column number which is illustrated by following figure. Pixel positions referenced by scan-line number and column number.
- To load the specified color into the frame buffer at a particular position, we will assume we have available low-level procedure of the form **setpixel(x,y)**.
- Similarly for retrieve the current frame buffer intensity we assume to have procedure **getpixel(x,y)**.



Graphics Packages:

There are mainly two types of graphics packages:

1. General programming package
2. Special-purpose application package

General programming package

- A general programming package provides an extensive set of graphics functions that can be used in high-level programming languages such as C or FORTRAN.
- It includes basic drawing elements like line, curves, polygon, color of element transformation etc.
- Example: – GL (Graphics Library).

Special-purpose application package

Special-purpose application packages are customized for particular applications which implement required facilities and provide an interface so that the user need not worry about how it will work (programming). The user can simply use it by interfacing with the application.

Example: – CAD, medical and business systems.

Input Devices:



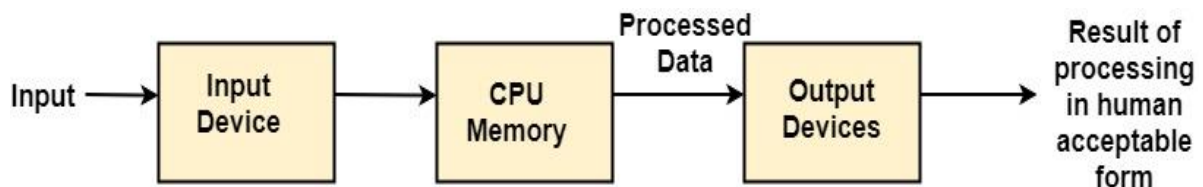
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The Input Devices are the hardware that is used to transfer transfers input to the computer. The data can be in the form of text, graphics, sound, and text. Output device display data from the memory of the computer. Output can be text, numeric data,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

Function of Keyboard:

1. Alphanumeric Keyboards are used in CAD. (Computer Aided Drafting)
2. Keyboards are available with special features line screen co-ordinates entry, Menu selection or graphics functions, etc.
3. Special purpose keyboards are available having buttons, dials, and switches. Dials are used to enter scalar values. Dials also enter real numbers. Buttons and switches are used to enter predefined function values.

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



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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.

Trackball

It is a pointing device. It is similar to a mouse. This is mainly used in notebook or laptop computer, instead of a mouse. This is a ball which is half inserted, and by changing fingers on the ball, the pointer can be moved.

Space ball:

It is similar to trackball, but it can move in six directions where trackball can move in two directions only. The movement is recorded by the strain gauge. Strain gauge is applied with pressure. It can be pushed and pulled in various directions. The ball has a diameter around 7.5 cm. The ball is mounted in the base using rollers. One-third of the ball is an inside box, the rest is outside.

Applications:

1. It is used for three-dimensional positioning of the object.
2. It is used to select various functions in the field of virtual reality.
3. It is applicable in CAD applications.
4. Animation is also done using spaceball.
5. It is used in the area of simulation and modeling.

Joystick:

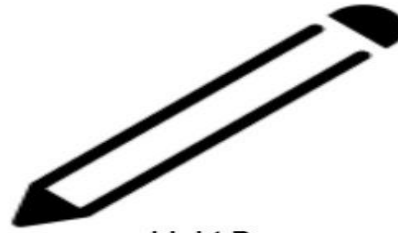
A Joystick is also a pointing device which is used to change cursor position on a monitor screen. Joystick is a stick having a spherical ball as it's both lower and upper ends as shown in fig.



The lower spherical ball moves in a socket. The joystick can be changed in all four directions. The function of a joystick is similar to that of the mouse. It is mainly used in Computer Aided Designing (CAD) and playing computer games.

Light Pen:

Light Pen (similar to the pen) is a pointing device which is used to select a displayed menu item or draw pictures on the monitor screen. It consists of a photocell and an optical system placed in a small tube. When its tip is moved over the monitor screen, and pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signals to the CPU.



Light Pen

Uses:

1. Light Pens can be used as input coordinate positions by providing necessary arrangements.
2. If background color or intensity, a light pen can be used as a locator.
3. It is used as a standard pick device with many graphics system.
4. It can be used as stroke input devices.
5. It can be used as valuator

Digitizers:



Digitizer

The digitizer is an operator input device, which contains a large, smooth board (the appearance is similar to the mechanical drawing board) & an electronic tracking device, which can be changed over the surface to follow existing lines. The electronic tracking device contains a switch for the user to record the desire x & y coordinate positions. The coordinates can be entered into the computer memory or stored on an off-line storage medium such as magnetic tape.

Touch Panels:

- Touch Panels is a type of display screen that has a touch-sensitive transparent panel covering the screen. A touch screen registers input when a finger or other object comes in contact with the screen.
- When the wave signals are interrupted by some contact with the screen, that located is recorded.
- Touch screens have long been used in military applications.

Voice Systems (Voice Recognition):

- Voice Recognition is one of the newest, most complex input techniques used to interact with the computer. The user inputs data by speaking into a microphone. The simplest form of voice recognition is a one-word command spoken by one person. Each command is isolated with pauses between the words.
- Voice Recognition is used in some graphics workstations as input devices to accept voice commands. The voice-system input can be used to initiate graphics operations or to



enter data. These systems operate by matching an input against a predefined dictionary of words and phrases.

Image Scanner

- It is an input device. The data or text is written on paper. The paper is fed to scanner. The paper written information is converted into electronic format; this format is stored in the computer. The input documents can contain text, handwritten material, picture extra.
- By storing the document in a computer document became safe for longer period of time. The document will be permanently stored for the future. We can change the document when we need. The document can be printed when needed.
- Scanning can be of the black and white or colored picture. On stored picture 2D or 3D rotations, scaling and other operations can be applied.

Output Devices in Computer Graphics:

Printers:

A printer is a peripheral device which is used to represent the graphics or text on paper. The quality is measured by its resolution. The resolution of any printer is measured in dot per inch (dpi).

The printer usually works with the computer and connected via a cable. In present, many digital device support printer features so that we can use Bluetooth, Wi-fi, and cloud technology to print.

Some types of printers are:

- Impact Printers
- Non-impact Printers

Impact Printers

In impact printers, there is a physical contact established between the print head, ribbon, ink-cartridge, and paper.

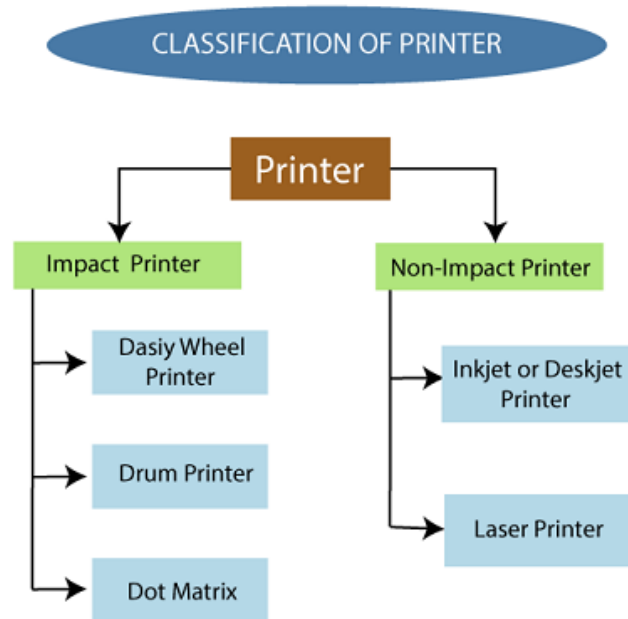
The printers hit print head on an ink-filled ribbon than the letter prints on the paper. Impact printers are works like a typewriter.

These printers have three types:

- Daisy Wheel Printers
- Drum Printers
- Dot Matrix Printer



Types of Printers:



Daisy Wheel Printers:

By these, we can print only one character at a time. The head of this printer looks like a daisy flower, with the printing arms that appear like petals of a flower; that's why it is called "**Daisy printer.**" It can print approx. 90 characters per second.



Daisy Wheel Printer

Daisy Wheel Printer

Daisy wheel printers are used to print the professional quality document. It is also called "**Letter Quality Printer.**"

Advantages:

1. More reliable
2. Better printing Quality

Disadvantages:

1. Slow than Dot Matrix
2. More Expensive
3. Noisy in operation



Drum Printers:

It has a shape like a drum, so it is called **"Drum Printer."** This type of printer contains many characters that are printed on the drum. The surface of the drum is broken down into the number of tracks. Total tracks are equal to character 132. A drum will have 132 tracks. The number of tracks is divided according to the width of the paper. It can print approx. 150-2500 lines per minute.



Drum Printer

Advantages:

1. High Speed
2. Low Cost

Disadvantages:

1. Poor Printing Quality
2. Noisy in Operation

Dot Matrix Printer:

It is also known as the **"Impact Matrix Printer."** Dot Matrix Printer can print only one character at a time. The dot matrix printer uses print heads consisting of 9 to 24 pins. These pins are used to produce a pattern of dots on the paper to create a separate character. Dot-matrix printer can print any shapes of character, special character, graphs, and charts.



Dot Matrix Printer



Advantages:

1. Low Printing Cost
2. Large print size
3. Long Life

Disadvantages:

1. Slow speed
2. Low Resolution

Non-impact Printers

In Non-impact printers, there is no physical contact between the print head or paper head. A non-impact printer prints a complete page at a time. The Non-impact printers spray ink on the paper through nozzles to form the letters and patterns. The printers that print the letters without the ribbon and on papers are called Non-impact printer. Non-impact printers are also known as “**Page Printer.**”

These printers have two types:

1. Inkjet Printer
2. Laser Printer

1. Inkjet Printer:

It is also called “**Deskjet Printer.**” It is a Non-impact printer in which the letters and graphics are printed by spraying a drop of ink on the paper with nozzle head.

A Color inkjet printer has four ink nozzles, sapphire, red, yellow, and black, so it is also called CMYK printer. We can produce any color by using these four colors. The prints and graphics of this printer are very clear. These printers are generally used for home purposes.



Inkjet Printer

Advantages:

1. High-Quality Printout
2. Low noise
3. High Resolution

Disadvantages:

1. Less Durability of the print head
2. Not suitable for high volume printing
3. Cartridges replacement is expensive



2. Laser Printer:

It is also called “**Page Printer**” because a laser printer process and store the whole page before printing it. The laser printer is used to produce high-quality images and text. Mostly it is used with personal computers. The laser printers are mostly preferred to print a large amount of content on paper.



Laser printer

Advantages:

1. High Resolution
2. High printing Speed
3. Low printing Cost

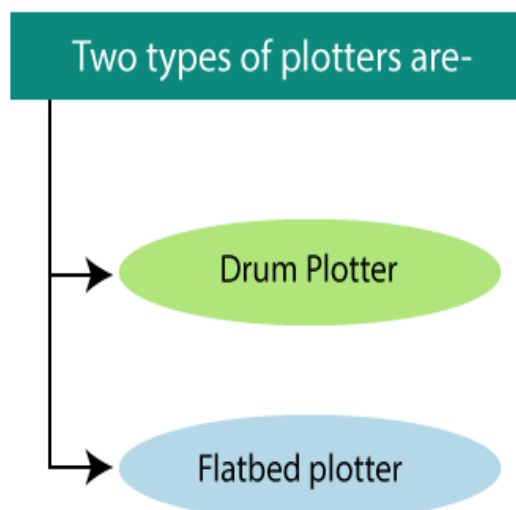
Disadvantages:

1. Costly than an inkjet printer
2. Larger and heavier than an inkjet printer

Plotters:

A plotter is a special type of output device. It is used to print large graphs, large designs on a large paper. **For Example:** Construction maps, engineering drawings, architectural plans, and business charts, etc. It was invented by “**Remington rand**” in 1953. It is similar to a printer, but it is used to print vector graphics.

Types of Plotter:





1. Flatbed Plotter:

In a flatbed plotter, the paper is kept in a stationary position on a table or a tray. A flatbed plotter has more than one pen and a holder. The pen rotates on the paper upside-down and right-left by the using of a motor. Every pen has a different color ink, which is used to draw the multicolor design. We can quickly draw the following designs by using a flatbed printer.

For Example: Cars, Ships, Airplanes, Dress design, road and highway blueprints, etc.



A Flatbed Plotter

Advantages of Flatbed Plotter

1. Larger size paper can be used
2. Drawing Quality is similar to an expert

Disadvantages of Flatbed Plotter

1. Slower than printers
2. More Expensive than printers
3. Do not produce high-Quality text printouts

Drum Plotter:

It is also called "**Roller plotter.**" There is a drum in this plotter. We can apply the paper on the drum. When the plotter works, these drums moves back and forth, and the image is drawn. Drum plotter has more than one pen and penholders. The pens easily moves right to left and left to right. The movement of pens and drums are controlled by graph plotting program. It is used in industry to produce large drawings (up to A0).



A Drum Plotter



Advantages of Drum Plotter:

1. Draw Larger Size image
2. We can print unlimited length of the image

Disadvantages of Drum Plotter:

1. Very costly

Visual Display Devices:

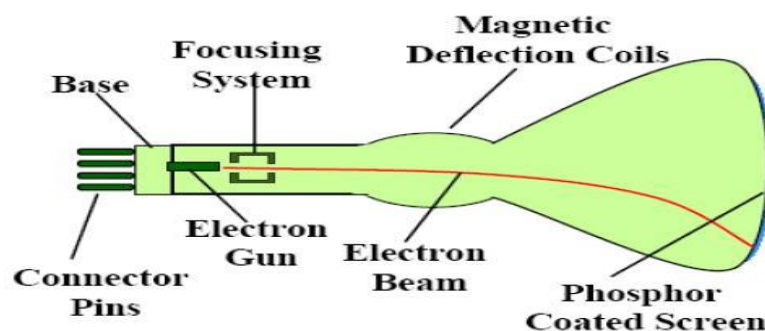
The primary output device in a graphics system is a video monitor. Although many technologies exist, but the operation of most video monitors is based on the standard Cathode Ray Tube (CRT) design.

Cathode Ray Tubes (CRT):

A cathode ray tube (CRT) is a specialized vacuum tube in which images are produced when an electron beam strikes a phosphorescent surface. It modulates, accelerates, and deflects electron beam(s) onto the screen to create the images. Most desktop computer displays make use of CRT for image displaying purposes.

Construction of a CRT:

1. The primary components are the **heated metal** cathode and a **control grid**.
2. The heat is supplied to the cathode (by passing current through the filament). This way the electrons get heated up and start getting ejected out of the cathode filament.
3. This stream of negatively charged electrons is accelerated towards the phosphor screen by supplying a high positive voltage.
4. This acceleration is generally produced by means of an accelerating anode.



Basic design of a magnetic deflection CRT

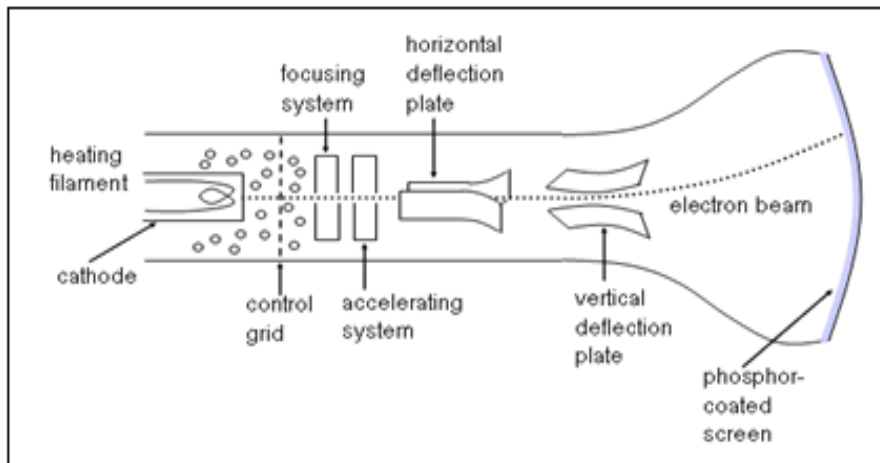
5. Next component is the **Focusing System**, which is used to force the electron beam to converge to small spot on the screen.
6. If there will not be any focusing system, the electrons will be scattered because of their own repulsions and hence we won't get a sharp image of the object.
7. This focusing can be either by means of electrostatic fields or magnetic fields.



Types of Deflection:

1. Electrostatic Deflection:

The electron beam (cathode rays) passes through a highly positively charged metal cylinder that forms an electrostatic lens. This electrostatic lens focuses the cathode rays to the center of the screen in the same way like an optical lens focuses the beam of light. Two pairs of parallel plates are mounted inside the CRT tube.



2. Magnetic Deflection:

Here, two pairs of coils are used. One pair is mounted on the top and bottom of the CRT tube, and the other pair on the two opposite sides. The magnetic field produced by both these pairs is such that a force is generated on the electron beam in a direction which is perpendicular to both the direction of magnetic field, and to the direction of flow of the beam. One pair is mounted horizontally and the other vertically.

- Different kinds of phosphors are used in a CRT. The difference is based upon the time for how long the phosphor continues to emit light after the CRT beam has been removed. This property is referred to as **Persistence**.
- The number of points displayed on a CRT is referred to as **resolutions** (eg. 1024x768).

Raster-Scan

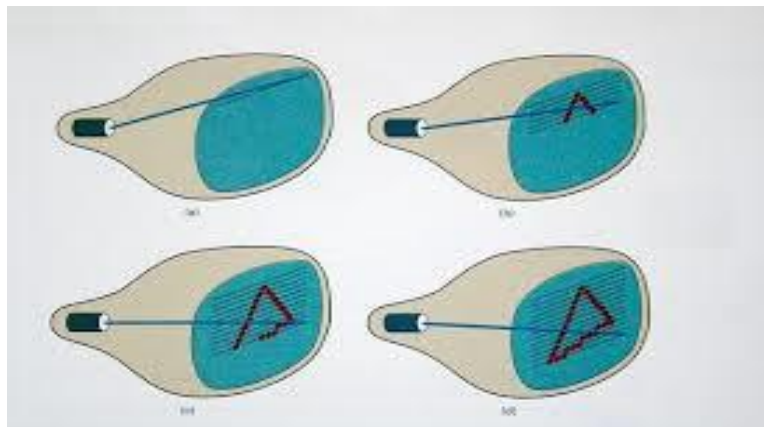
- The electron beam is swept across the screen one row at a time from top to bottom. As it moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots. This scanning process is called refreshing.
- Each complete scanning of a screen is normally called a frame. The refreshing rate, called the frame rate, is normally 60 to 80 frames per second, or described as 60 Hz to 80 Hz.
- Picture definition is stored in a memory area called the frame buffer.
- This frame buffer stores the intensity values for all the screen points. Each screen point is called a pixel (picture element or pel).
- On black and white systems, the frame buffer storing the values of the pixels is called a **bitmap**. Each entry in the bitmap is a 1-bit data which determines the on (1) and off (0) of the intensity of the pixel.



On color systems, the frame buffer storing the values of the pixels is called a **pixmap** (Though nowadays many graphics libraries name it as bitmap too). Each entry in the pixmap occupies a number of bits to represent the color of the pixel. For a true color display, the number of bits for each entry is 24 (8 bits per red/green/blue channel, each channel 256 levels of intensity value, ie. 256 voltage settings for each of the red/green/blue electron guns).

Random-Scan (Vector Display) or stroke-writing or calligraphic displays:

The CRT's electron beam is directed only to the parts of the screen where a picture is to be drawn. The picture definition is stored as a set of line-drawing commands in a refresh display file or a refresh buffer in memory.

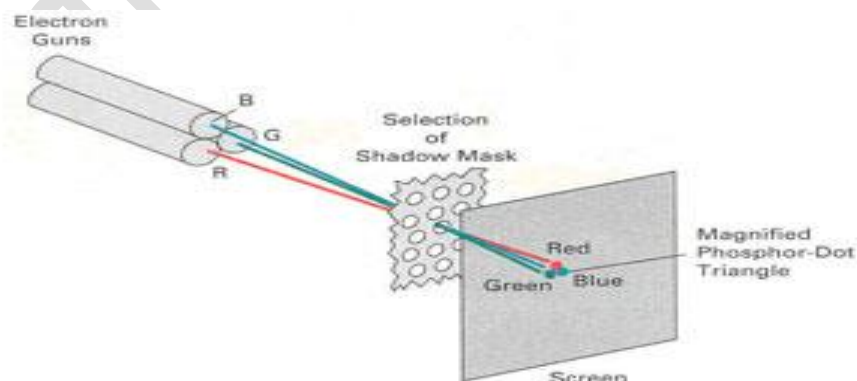


Random-scan generally have higher resolution than raster systems and can produce smooth line drawings, however it cannot display realistic shaded scenes.

Color CRT Monitors:

The CRT Monitor display by using a combination of phosphors. The phosphors are different colors. There are two popular approaches for producing color displays with a CRT are:

1. Beam Penetration Method
2. Shadow-Mask Method



1. Beam Penetration Method:

The Beam-Penetration method has been used with random-scan monitors. In this method, the CRT screen is coated with two layers of phosphor, red and green and the displayed



color depends on how far the electron beam penetrates the phosphor layers. This method produces four colors only, red, green, orange and yellow. A beam of slow electrons excites the outer red layer only; hence screen shows red color only. A beam of high-speed electrons excites the inner green layer. Thus screen shows a green color.

Advantages:

1. Inexpensive

Disadvantages:

1. Only four colors are possible
2. Quality of pictures is not as good as with another method.

2. Shadow-Mask Method:

- Shadow Mask Method is commonly used in Raster-Scan System because they produce a much wider range of colors than the beam-penetration method.
- It is used in the majority of color TV sets and monitors.

Construction:

A shadow mask CRT has 3 phosphor color dots at each pixel position.

- One phosphor dot emits: red light
- Another emits: green light
- Third emits: blue light

This type of CRT has 3 electron guns, one for each color dot and a shadow mask grid just behind the phosphor coated screen. Shadow mask grid is pierced with small round holes in a triangular pattern.

Working:

- The deflection system of the CRT operates on all 3 electron beams simultaneously; the 3 electron beams are deflected and focused as a group onto the shadow mask, which contains a sequence of holes aligned with the phosphor-dot patterns.
- When the three beams pass through a hole in the shadow mask, they activate a dotted triangle, which occurs as a small color spot on the screen.
- The phosphor dots in the triangles are organized so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.

Advantage:

1. Realistic image
2. Million different colors to be generated
3. Shadow scenes are possible

Disadvantage:

1. Relatively expensive compared with the monochrome CRT.
2. Relatively poor resolution
3. Convergence Problem

Direct View Storage Tubes:

DVST terminals also use the random scan approach to generate the image on the CRT screen. The term "storage tube" refers to the ability of the screen to retain the image which has been projected against it, thus avoiding the need to rewrite the image constantly.



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Function of guns:

Two guns are used in DVST:

1. **Primary guns:** It is used to store the picture pattern.
2. **Flood gun or Secondary gun:** It is used to maintain picture display.

Advantage:

1. No refreshing is needed.
2. High Resolution
3. Cost is very less

Disadvantage:

1. It is not possible to erase the selected part of a picture.
2. It is not suitable for dynamic graphics applications.
3. If a part of picture is to modify, then time is consumed.

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.

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).

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 glow 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:

1. Low power consumption.
2. Small Size
3. Low Cost

Disadvantage:

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



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Differences between Raster Scan Display and Random Scan Display:

Base of Differences	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 part 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 pixels 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.