

What is Computer Graphics?

Computer graphics is an art of drawing pictures, lines, charts, etc. using computers with the help of programming. Computer graphics image is made up of number of pixels. **Pixel** is the smallest addressable graphical unit represented on the computer screen.

Computer is information processing machine. User needs to communicate with computer and the computer graphics is one of the most effective and commonly used ways of communication with the user. It displays the information in the form of graphical objects such as pictures, charts, diagram and graphs. Graphical objects convey more information in less time and easily understandable formats for example statically graph shown in stock exchange. In computer graphics picture or graphics objects are presented as a collection of discrete pixels. We can control intensity and color of pixel which decide how picture look like. The special procedure determines which pixel will provide the best approximation to the desired picture or graphics object this process is known as **Rasterization**. The process of representing continuous picture or graphics object as a collection of discrete pixels is called **Scan Conversion**.

Advantages of computer graphics

Computer graphics is one of the most effective and commonly used ways of communication with computer. It provides tools for producing picture of “real-world” as well as synthetic objects such as mathematical surfaces in 4D and of data that have no inherent geometry such as survey result. It has ability to show moving pictures thus possible to produce animations with computer graphics. With the use of computer graphics we can control the animation by adjusting the speed, portion of picture in view the amount of detail shown and so on. It provides tools called motion dynamics. In which user can move objects as well as observes as per requirement for example walk throw made by builder to show flat interior and surrounding. It provides facility called update dynamics. With this we can change the shape color and other properties of object. Now in recent development of digital signal processing and audio synthesis chip the interactive graphics can now provide audio feedback along with the graphical feed backs.

Application of computer graphics

- User interface: - Visual object which we observe on screen which communicates with user is one of the most useful applications of the computer graphics.
- Plotting of graphics and chart in industry, business, government and educational organizations drawing like bars, pie-charts, histogram's are very useful for quick and good decision making.
- Office automation and desktop publishing: - It is used for creation and dissemination of information. It is used in in-house creation and printing of documents which contains text, tables, graphs and other forms of drawn or scanned images or picture.
- Computer aided drafting and design: - It uses graphics to design components and system such as automobile bodies structures of building etc.
- Simulation and animation: - Use of graphics in simulation makes mathematic models and mechanical systems more realistic and easy to study.
- Art and commerce: - There are many tools provided by graphics which allows used to make their picture animated and attracted which are used in advertising.
- Process control: - Now a day's automation is used which is graphically displayed on the screen.
- Cartography: - Computer graphics is also used to represent geographic maps, weather maps, oceanographic charts etc.
- Education and training: - Computer graphics can be used to generate models of physical, financial and economic systems. These models can be used as educational aids.

➤ Image processing: - It is used to process image by changing property of the image.

Representative Uses of Computer Graphics :

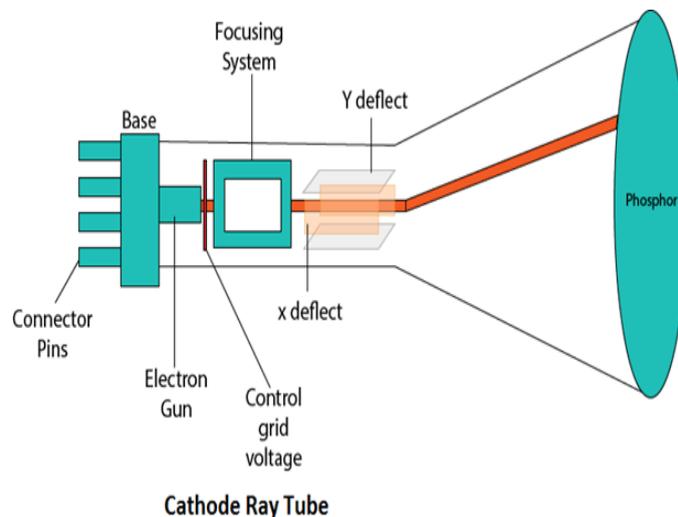
- **User interfaces:** GUI, etc.
- **Business, science and technology:** histograms, bar and pie charts, etc.
- **Office automation and electronic publishing:** text , tables, graphs, hypermedia systems, etc.
- **Computer-aided design (CAD):** structures of building, automobile bodies, etc.
- **Simulation and animation for scientific visualization and entertainment:** flight simulation , games, movies, virtual reality, etc.
- **Art and commerce:** terminals in public places such as museums, etc.
- **Cartography:** map making.

Cathode-ray tube:

The CRT is a display screen which produces images in the form of the video signal. It is a type of vacuum tube which displays images when the electron beam through electron guns are strikes on the phosphorescent surface. In other Words, the CRT generates the beams, accelerates it at high velocity and deflect it for creating the images on the phosphorous screen so that the beam becomes visible.

CRT stands for Cathode Ray Tube. CRT is a technology used in traditional computer monitors and televisions. The image on CRT display is created by firing electrons from the back of the tube of phosphorus located towards the front of the screen.

Once the electron heats the phosphorus, they light up, and they are projected on a screen. The color you view on the screen is produced by a blend of red, blue and green light.



Components of CRT:

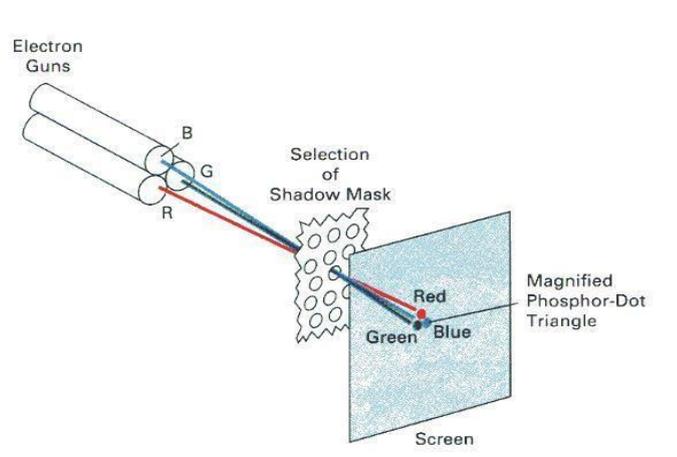
1. **Electron Gun:** Electron gun consisting of a series of elements, primarily a heating filament (heater) and a cathode. The electron gun creates a source of electrons which are focused into a narrow beam directed at the face of the CRT.

2. **Control Electrode:** It is used to turn the electron beam on and off.

3. **Focusing system:** It is used to create a clear picture by focusing the electrons into a narrow beam.

4. **Deflection Yoke:** It is used to control the direction of the electron beam. It creates an electric or magnetic field which will bend the electron beam as it passes through the area. In a conventional CRT, the yoke is linked to a sweep or scan generator. The deflection yoke which is connected to the sweep generator creates a fluctuating electric or magnetic potential.

5. **Phosphorus-coated screen:** The inside front surface of every CRT is coated with phosphors. Phosphors glow when a high-energy electron beam hits them. Phosphorescence is the term used to characterize the light given off by a phosphor after it has been exposed to an electron beam.



- An electron gun at the rear of the tube produce a beam of electrons which is directed towards the screen of the tube by a high voltage typically 15000 to 20000 volts
- Inner side screen is coated with phosphor substance which gives light when it is stroked by electrons.
- Control grid controls velocity of electrons before they hit the phosphor.
- The control grid voltage determines how many electrons are actually in the electron beam. The negative the Thus control grid controls Intensity of the spot where beam strikes the screen.
- The focusing system concentrates the electron beam so it converges to small point when hits the phosphor coating.
- Deflection system directs beam which decides the point where beam strikes the screen.
- Deflection system of the CRT consists of two pairs of parallel plates which are vertical and horizontal deflection plates.
- Voltage applied to vertical and horizontal deflection plates is control vertical and horizontal deflection respectively.
- control voltage is the fewer the electrons that pass through the grid.

Two Techniques to Display Image on CRT:

- Vector scan/Random scan display.
- Raster scan display.

Vector scan/Random scan display:

In **Random-Scan Display** electron beam is directed only to the areas of screen where a picture has to be drawn. It is also called vector displays, as it draws picture one line at a time. It can draw and refresh component lines of a picture in any specified sequence. Pen plotter is an example of random-scan displays.

Vector scan/Random scan display

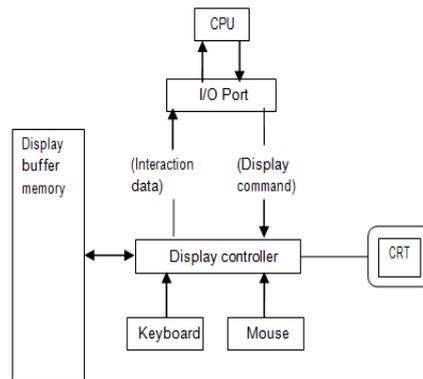
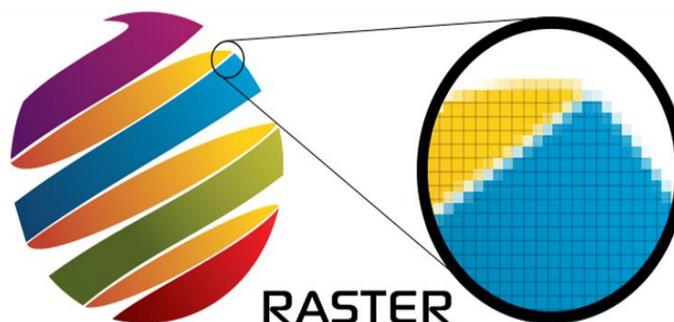


Fig. 1.2: - Architecture of a vector display.

Vector scan display directly traces out only the desired lines on CRT. If we want line between point p1 & p2 then we directly drive the beam deflection circuitry which focus beam directly from point p1 to p2. If we do not want to display line from p1 to p2 and just move then we can blank the beam as we move it. To move the beam across the CRT, the information about both magnitude and direction is required. This information is generated with the help of vector graphics generator. It consists of display controller, CPU, display buffer memory and CRT. Display controller is connected as an I/O peripheral to the CPU. Display buffer stores computer produced display list or display program. The Program contains point & line plotting commands with end point co-ordinates as well as character plotting commands. Display controller interprets command and sends digital and point co-ordinates to a vector generator. Vector generator then converts the digital co-ordinate value to analog voltages for beam deflection circuits that displace an electron beam which points on the CRT's screen. In this technique beam is deflected from end point to end point hence this techniques is also called random scan. We know as beam strikes phosphors coated screen it emits light but that light decays after few milliseconds and therefore it is necessary to repeat through the display list to refresh the screen at least 30 times per second to avoid flicker. As display buffer is used to store display list and used to refreshing, it is also called refresh buffer.

RASTER DISPLAY ARCHITECTURE:

An image is subdivided into various horizontal lines which are referred to as scan lines which are then further divided into different pixels which helps in the processing of an image.



Raster scan display

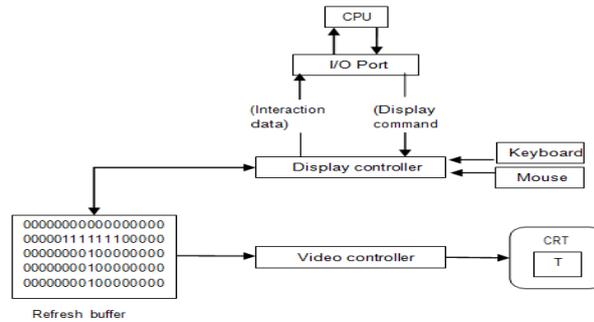
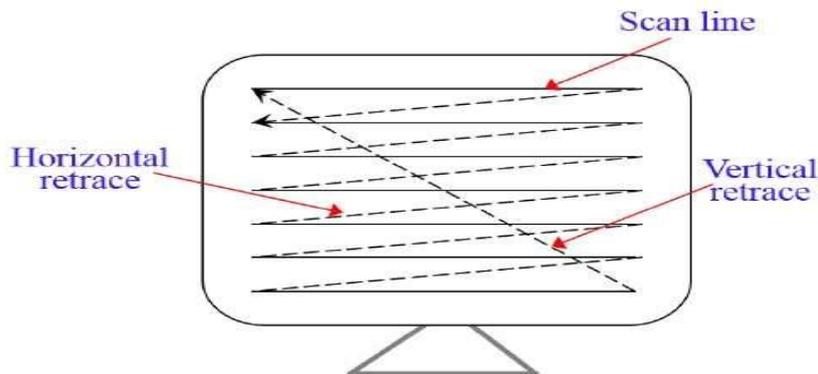


Fig. 1.3: - Architecture of a raster display.

- In this system, a beam of an electron is moved across the screen. It moves from top to bottom considering one row at a time.
- As the beam of electron moves through each row, its intensity is alternatively turned on and off which helps to create a pattern of spots that are illuminated. When each scan of the line is refreshed it returns to the left side of the screen. This motion is known as **Horizontal retrace**.
- As a particular frame ends, the beam of electron moves to the left top corner of the screen to move to another frame. This motion is referred to as **Vertical retrace**.
- The picture is then stored in an area of memory which is referred to as the **frame buffer** or **refresh buffer**.
- The buffer in a raster scan is that area that is responsible for containing intensity of the various points on the screen.
- The values stored in the buffer are then fetched and traced over scan lines one by one on the screen.



- The image formed through this raster scan is known as a raster image. The quality of this image is determined by the number of pixels which is termed as the **resolution of the image**.
- The amount of information each pixel represents is known as the **color depth of the image**.
- The raster graphics system of high quality contains 24 bits per pixel in the frame buffer. This is referred to as a **full color** or **true color** system. Refreshing of raster scan displays is carried out at the rate of 60 to 80 frames per second.

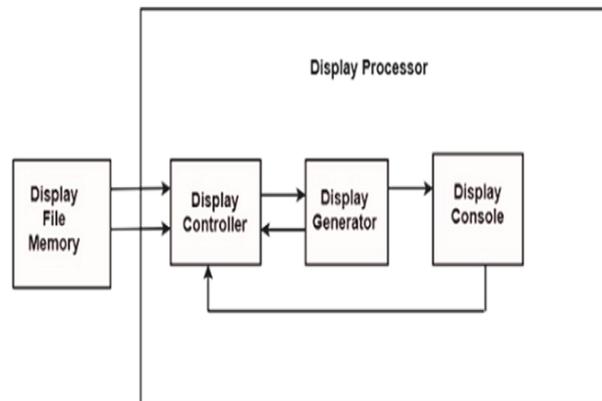
DISPLAY PROCESSOR:

Display Processor is a part of computer graphics which is used to convert the code into pictures. In other words, we can say that the Display Processor is used to convert the digital information or the digital signal into analog. The display Processor in simple terms can also be called *digital to analog converter*. The conversion in the Display Processors depends on the types of devices and the functions used for graphical representations. The main purpose of the Display Processor is scan conversion. Scan Conversion is a process of displaying different graphics objects as a collection of pixels. In this process, we have to differentiate graphics objects a collection of different mathematical shapes like ellipse, rectangle, and polygons. It is also called **Display Processing Unit**, DPU in short.

Parts of Display Processor:

There are 4 major parts of the Display Processor,

- Display File Memory
- Display Controller
- Display Generator
- Display Console



Display File Memory

- It is used to display the pictures on the screen.
- The Display File Memory identifies the different graphics objects or entities.
- All the pixel values that are to be showed on the screen are there in the display File memory.

Display Controller

- The Display Controller handles the flow instructions in the display processor.
- It is responsible for handling the interrupt and to maintain the timings between their executions.
- Interpretation of the instructions is also performed by the Display Controller.

Display Generator

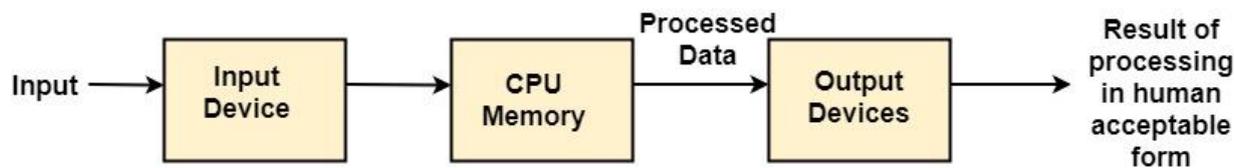
- Display Generator is used to generate characters and shapes on the screen.
- This displays the shapes and characters according to the input we give in it.
- The Display Generator is used for generating curves and characters on the screen.

Display Console

- Display Console is a combination of a display device and an input device.
- This is the part of the Display Processor which shows the output on the screen.
- The Cathode Ray Tube comes under the Display Console. In common terms, the display console is the screen on which you see all your graphical outputs.

INPUT & OUTPUT 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.



Keyboards

- Keyboards are used as entering text strings. It is efficient devices for inputting such a non-graphics data as picture label.
- Cursor control key's & function keys are common features on general purpose keyboards.
- Many other application of key board which we are using daily used of computer graphics are commanding & controlling through keyboard etc.

Mouse

- Mouse is small size hand-held box used to position screen cursor.
- Wheel or roller or optical sensor is directing pointer on the according to movement of mouse.
- Three buttons are placed on the top of the mouse for signaling the execution of some operation.
- Now a day's more advance mouse is available which are very useful in graphics application for example Z mouse.

Trackball and Spaceball

- Trackball is ball that can be rotated with the finger or palm of the hand to produce cursor movement.
- Potentiometer attached to the ball, measure the amount and direction of rotation.
- They are often mounted on keyboard or Z mouse.
- Space ball provide six-degree of freedom i.e. three dimensional.
- In space ball strain gauges measure the amount of pressure applied to the space ball to provide input for spatial positioning and orientation as the ball is pushed or pulled in various directions.
- Space balls are used in 3D positioning and selection operations in virtual reality system, modeling, animation, CAD and other application.

Joysticks

- A joy stick consists of small vertical lever mounted on a base that is used to steer the screen cursor around.
- Most joy sticks selects screen positioning according to actual movement of stick (lever).
- Some joy sticks are works on pressure applied on sticks.
- Sometimes joy stick mounted on keyboard or sometimes used alone.
- Movement of the stick defines the movement of the cursor.
- In pressure sensitive stick pressure applied on stick decides movement of the cursor. This pressure is measured using strain gauge.
- This pressure sensitive joy sticks also called as isometric joy sticks and they are non movable sticks.

Data glove

- Data glove is used to grasp virtual objects.
- The glow is constructed with series of sensors that detect hand and figure motions.
- Electromagnetic coupling is used between transmitter and receiver antennas which used to provide position and orientation of the hand.
- Transmitter & receiver Antenna can be structured as a set of three mutually perpendicular coils forming 3D Cartesian coordinates system.
- Input from the glove can be used to position or manipulate object in a virtual scene.

Digitizer

- Digitizer is common device for drawing painting or interactively selecting coordinates position on an object.
- One type of digitizers is graphics tablet which input two dimensional coordinates by activating hand cursor or stylus at selected position on a flat surface.
- Stylus is flat pencil shaped device that is pointed at the position on the tablet.

Image Scanner

- Image Scanner scan drawing, graph, color, & black and white photos or text and can stored for computer processing by passing an optical scanning mechanism over the information to be stored.
- Once we have internal representation of a picture we can apply transformation.
- We can also apply various image processing methods to modify the picture.
- For scanned text we can apply modification operation.

Touch Panels

- As name suggest Touch Panels allow displaying objects or screen-position to be selected with the touch or finger.
- A typical application is selecting processing option shown in graphical icons.
- Some system such as a plasma panel are designed with touch screen
- Other system can be adapted for touch input by fitting transparent touch sensing mechanism over a screen.
- Touch input can be recorded with following methods.
 1. Optical methods
 2. Electrical methods

3. Acoustical methods

Optical method

- Optical touch panel employ a line of infrared LEDs along one vertical and one horizontal edge.
- The opposite edges of the edges containing LEDs are contain light detectors.
- When we touch at a particular position the line of light path breaks and according to that breaking line coordinate values are measured.
- In case two line cuts it will take average of both pixel positions.
- LEDs operate at infrared frequency so it cannot be visible to user.

Electrical method

- An electrical touch panel is constructed with two transparent plates separated by small distance.
- One is coated with conducting material and other is coated with resistive material.
- When outer plate is touch it will come into contact with internal plate.
- When both plates touch it creates voltage drop across the resistive plate that is converted into coordinate values of the selected position.

Acoustical method

- In acoustical touch panel high frequency sound waves are generated in horizontal and vertical direction across a glass plates.
- When we touch the screen the waves from that line are reflected from finger.
- These reflected waves reach again at transmitter position and time difference between sending and receiving is measure and converted into coordinate values.

Light pens

- Light pens are pencil-shaped device used to select positions by detecting light coming from points on the CRT screen.
- Activated light pens pointed at a spot on the screen as the electron beam lights up that spot and generate electronic pulse that causes the coordinate position of the electron beam to be recorded.

Voice systems

- It is used to accept voice command in some graphics workstations.
- It is used to initiate graphics operations.
- It will match input against predefined directory of words and phrases.
- Dictionary is setup for a particular operator by recording his voice.
- Each word is speak several times and then analyze the word and establishes a frequency pattern for that word along with corresponding function need to be performed.
- When operator speaks command it will match with predefine dictionary and perform desired action.

Graphics software and standard

- There are mainly two types of graphics software:
 1. General programming package
 2. Special-purpose application package

General programming package

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

Special-purpose application package

- Special-purpose application package are customize for particular application which implement required facility and provides interface so that user need not to vory about how it will work (programming). User can simply use it by interfacing with application.
- Example: - CAD, medical and business systems.

Coordinate representations

- Except few all other general packages are designed to be used with Cartesian coordinate specifications.
- If coordinate values for a picture are specified is some other reference frame they must be converted to Cartesian coordinate before giving input to graphics package.
- Special-purpose package may allow use of other coordinates which suits application.
- In general several different Cartesian reference frames are used to construct and display scene.
- We can construct shape of object with separate coordinate system called modeling coordinates or sometimes local coordinates or master coordinates.
- Once individual object shapes have been specified we can place the objects into appropriate positions called world coordinates.
- Finally the World-coordinates description of the scene is transferred to one or more output device reference frame for display. These display coordinates system are referred to as “**Device Coordinates**” or “**Screen Coordinates**”.
- Generally a graphic system first converts the world-coordinates position to normalized device coordinates. In the range from 0 to 1 before final conversion to specific device coordinates.
- An initial modeling coordinates position (X_{mc}, Y_{mc}) in this illustration is transferred to a device coordinates position(X_{dc}, Y_{dc}) with the sequence (X_{mc}, Y_{mc}) □ (X_{wc}, Y_{wc}) □ (X_{nc}, Y_{nc}) □ (X_{dc}, Y_{dc}).

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- https://en.wikipedia.org/wiki/Computer_graphics#:~:text=Computer%20graphics%20is%20the%20branch,with%20the%20aid%20of%20computers.&text=It%20is%20a%20vast%20and,and%20William%20Fetter%20of%20Boeing.
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