

## Computer Graphics

It is difficult to display an image of any size on the computer screen. This method is simplified by using Computer graphics. Graphics on the computer are produced by using various algorithms and techniques. This tutorial describes how a rich visual experience is provided to the user by explaining how all these processed by the computer.

### Introduction of Computer Graphics

Computer Graphics involves technology to access. The Process transforms and presents information in a visual form. The role of computer graphics insensible. In today life, computer graphics has now become a common element in user interfaces, T.V. commercial motion pictures.

Computer Graphics is the creation of pictures with the help of a computer. The end product of the computer graphics is a picture it may be a business graph, drawing, and engineering.

In computer graphics, two or three-dimensional pictures can be created that are used for research. Many hardware devices algorithm has been developing for improving the speed of picture generation with the passes of time. It includes the creation storage of models and image of objects. These models for various fields like engineering, mathematical and so on.

Today computer graphics is entirely different from the earlier one. It is not possible. It is an interactive user can control the structure of an object of various input devices.

### Definition of Computer Graphics:

It is the use of computers to create and manipulate pictures on a display device. It comprises of software techniques to create, store, modify, represents pictures.

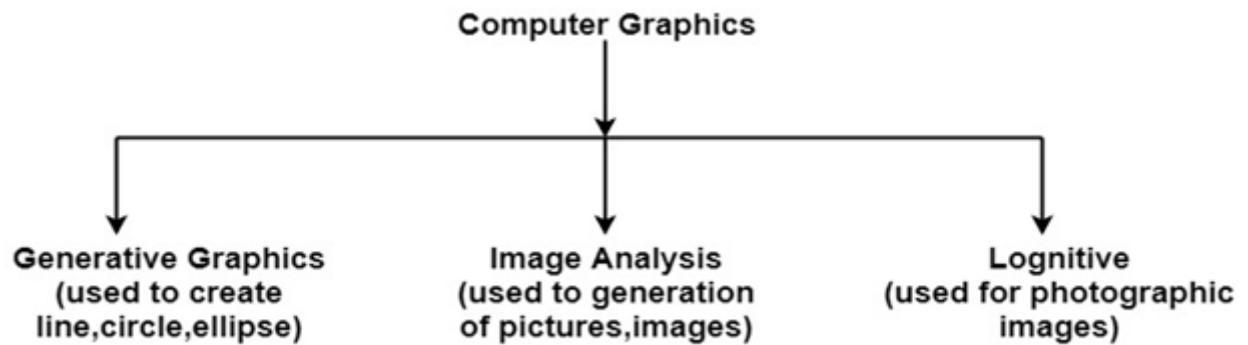
Or

Computer graphics refers to a technology that generates images on a computer screen. It's used in digital photography, film and television, video games, and on electronic devices and is responsible for displaying images effectively to users.

### Why computer graphics used?

Suppose a shoe manufacturing company want to show the sale of shoes for five years. For this vast amount of information is to store. So a lot of time and memory will be needed. This method will be tough to understand by a common man. In this situation graphics is a better alternative. Graphics tools are charts and graphs. Using graphs, data can be represented in pictorial form. A picture can be understood easily just with a single look.

Interactive computer graphics work using the concept of two-way communication between computer users. The computer will receive signals from the input device, and the picture is modified accordingly. Picture will be changed quickly when we apply command.



### Application of Computer Graphics

**1. Education and Training:** Computer-generated model of the physical, financial and economic system is often used as educational aids. Model of physical systems, physiological system, population trends or equipment can help trainees to understand the operation of the system.

For some training applications, particular systems are designed. For example Flight Simulator.

**Flight Simulator:** It helps in giving training to the pilots of airplanes. These pilots spend much of their training not in a real aircraft but on the ground at the controls of a Flight Simulator.

### Advantages:

1. Fuel Saving
2. Safety
3. Ability to familiarize the training with a large number of the world's airports.

**2. Use in Biology:** Molecular biologist can display a picture of molecules and gain insight into their structure with the help of computer graphics.

**3. Computer-Generated Maps:** Town planners and transportation engineers can use computer-generated maps which display data useful to them in their planning work.

**4. Architect:** Architect can explore an alternative solution to design problems at an interactive graphics terminal. In this way, they can test many more solutions that would not be possible without the computer.

**5. Presentation Graphics:** Example of presentation Graphics are bar charts, line graphs, pie charts and other displays showing relationships between multiple parameters. Presentation Graphics is commonly used to summarize

- Financial Reports
- Statistical Reports

- Mathematical Reports
- Scientific Reports
- Economic Data for research reports
- Managerial Reports
- Consumer Information Bulletins
- And other types of reports

**6. Computer Art:** Computer Graphics are also used in the field of commercial arts. It is used to generate television and advertising commercial.

**7. Entertainment:** Computer Graphics are now commonly used in making motion pictures, music videos and television shows.

**8. Visualization:** It is used for visualization of scientists, engineers, medical personnel, business analysts for the study of a large amount of information.

**9. Educational Software:** Computer Graphics is used in the development of educational software for making computer-aided instruction.

**10. Printing Technology:** Computer Graphics is used for printing technology and textile design.

#### **Example of Computer Graphics Packages:**

1. LOGO
2. COREL DRAW
3. AUTO CAD
4. 3D STUDIO
5. CORE
6. GKS (Graphics Kernel System)
7. PHIGS
8. CAM (Computer Graphics Metafile)
9. CGI (Computer Graphics Interface)

**Graphical User Interface:**

The use of pictures, images, icons, pop-up menus, graphical objects helps in creating a user friendly environment where working is easy and pleasant, using computer graphics we can create such an atmosphere where everything can be automated and anyone can get the desired action performed in an easy fashion.

**Image Processing:**

Various kinds of photographs or images require editing in order to be used in different places. Processing of existing images into refined ones for better interpretation is one of the many applications of computer graphics.

**Machine Drawing:**

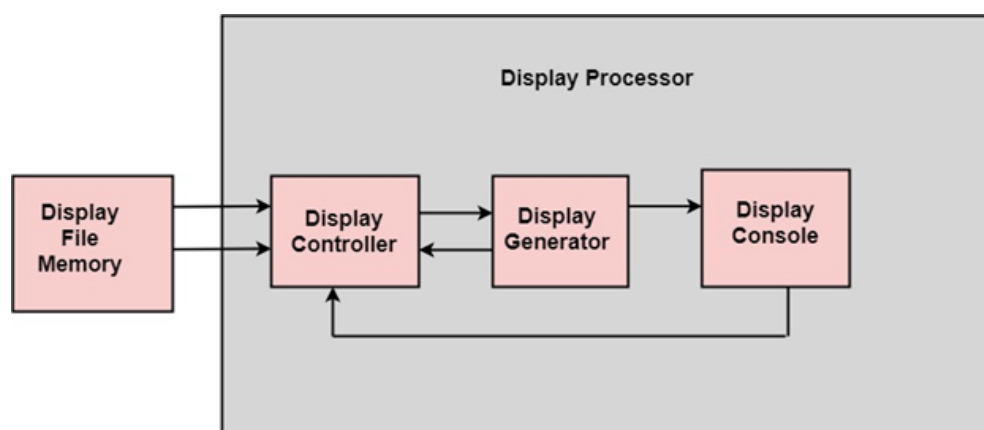
Computer graphics is very frequently used for designing, modifying and creation of various parts of machine and the whole machine itself, the main reason behind using computer graphics for this purpose is the precision and clarity we get from such drawing is ultimate and extremely desired for the safe manufacturing of machine using these drawings.

**Display Processor:**

It is interpreter or piece of hardware that converts display processor code into pictures. It is one of the four main parts of the display processor

Parts of Display Processor

1. Display File Memory
2. Display Processor
3. Display Generator
4. Display Console



Block diagram of Display System

**Display File Memory:** It is used for generation of the picture. It is used for identification of graphic entities.

### Display Controller:

1. It handles interrupt
2. It maintains timings
3. It is used for interpretation of instruction.

### Display Generator:

1. It is used for the generation of character.
2. It is used for the generation of curves.

**Display Console:** It contains CRT, Light Pen, and Keyboard and deflection system.

The raster scan system is a combination of some processing units. It consists of the control processing unit (CPU) and a particular processor called a display controller. Display Controller controls the operation of the display device. It is also called a video controller.

**Working:** The video controller in the output circuitry generates the horizontal and vertical drive signals so that the monitor can sweep. Its beam across the screen during raster scans.

As fig showing that 2 registers (X register and Y register) are used to store the coordinate of the screen pixels. Assume that y values of the adjacent scan lines increased by 1 in an upward direction starting from 0 at the bottom of the screen to  $y_{\max}$  at the top and along each scan line the screen pixel positions or x values are incremented by 1 from 0 at the leftmost position to  $x_{\max}$  at the rightmost position.

The origin is at the lowest left corner of the screen as in a standard Cartesian coordinate system.



**Fig:**The origin of the coordinate system for identifying screen positions is usually specified in the lower-left corner.

At the start of a **Refresh Cycle**:

X register is set to 0 and y register is set to  $y_{\max}$ . This (x, y) address is translated into a memory address of frame buffer where the color value for this pixel position is stored.

The controller receives this color value (a binary no) from the frame buffer, breaks it up into three parts and sends each element to a separate Digital-to-Analog Converter (DAC).

These voltages, in turn, controls the intensity of 3 e-beam that are focused at the (x, y) screen position by the horizontal and vertical drive signals.

This process is repeated for each pixel along the top scan line, each time incrementing the X register by Y.

As pixels on the first scan line are generated, the X register is incremented through  $x_{\max}$ .

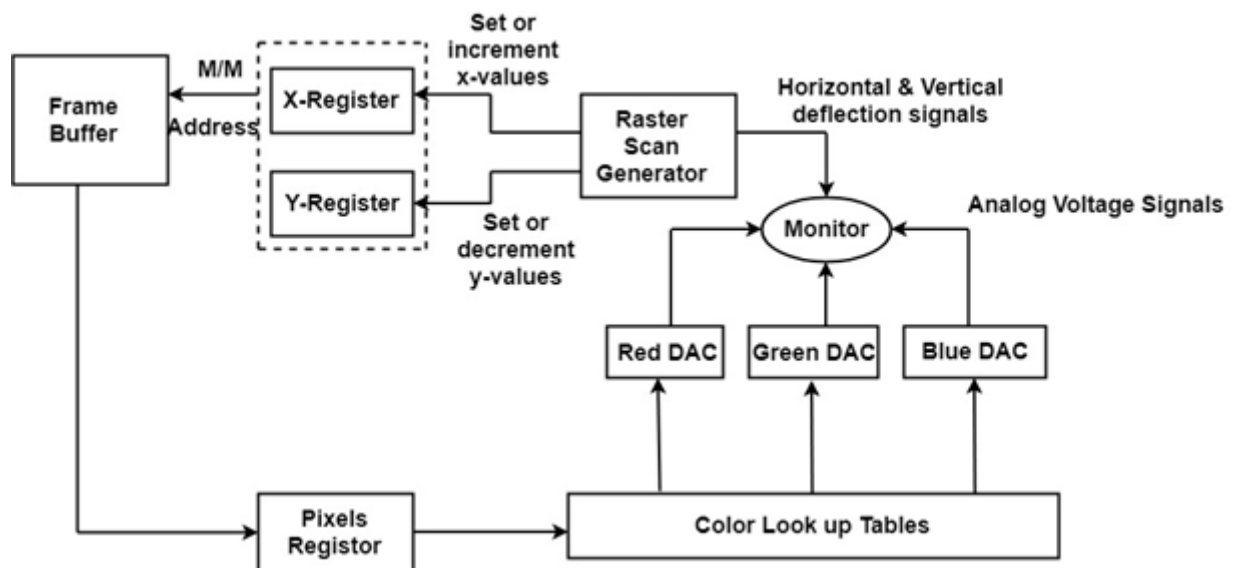
Then x register is reset to 0, and y register is decremented by 1 to access the next scan line.

Pixel along each scan line is then processed, and the procedure is repeated for each successive scan line units pixels on the last scan line ( $y=0$ ) are generated.

For a display system employing a color look-up table frame buffer value is not directly used to control the CRT beam intensity.

It is used as an index to find the three pixel-color value from the look-up table. This lookup operation is done for each pixel on every display cycle.

As the time available to display or refresh a single pixel in the screen is too less, accessing the frame buffer every time for reading each pixel intensity value would consume more time what is allowed:



Multiple adjacent pixel values are fetched to the frame buffer in single access and stored in the register.

After every allowable time gap, the one-pixel value is shifted out from the register to control the warm intensity for that pixel.

The procedure is repeated with the next block of pixels, and so on, thus the whole group of pixels will be processed.

### **Display Devices:**

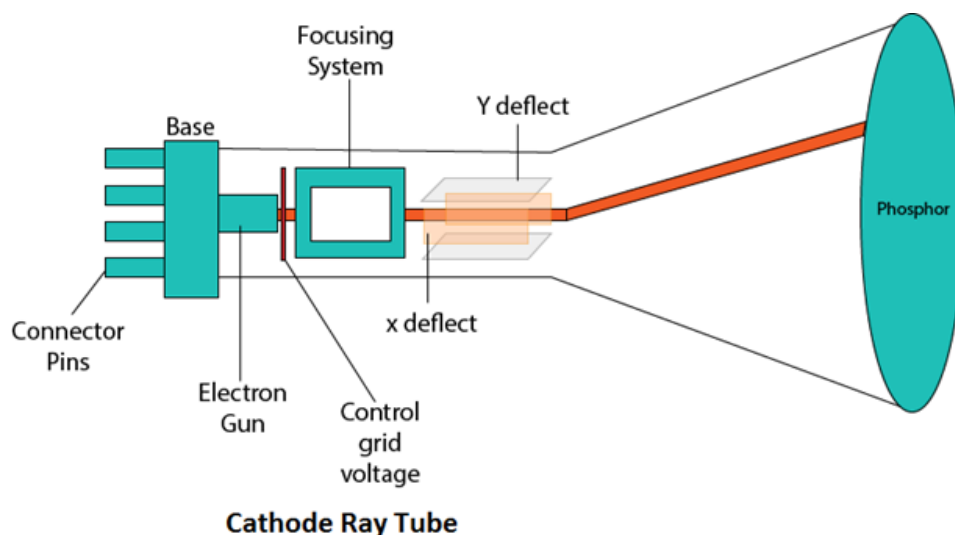
The most commonly used display device is a video monitor. The operation of most video monitors based on CRT (Cathode Ray Tube). The following display devices are used:

1. Refresh Cathode Ray Tube
2. Random Scan and Raster Scan
3. Color CRT Monitors
4. Direct View Storage Tubes
5. Flat Panel Display
6. Lookup Table

### **Cathode Ray Tube (CRT):**

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:**

Main Components of CRT are:

**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.

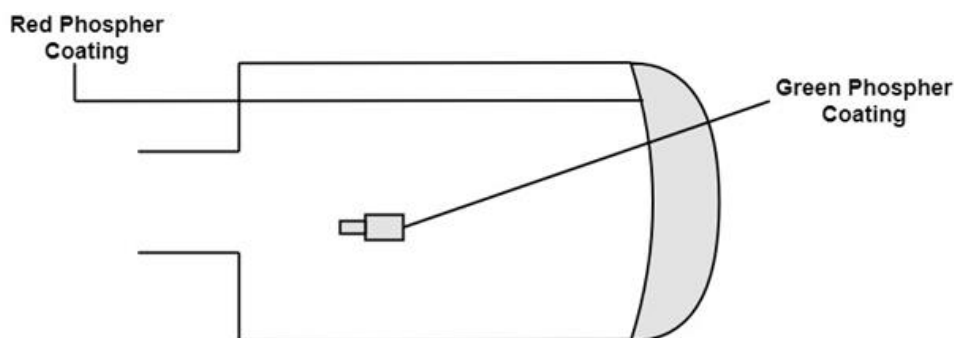
### **Color CRT Monitors:**

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.

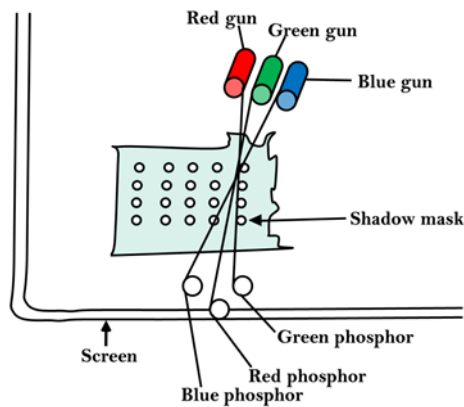
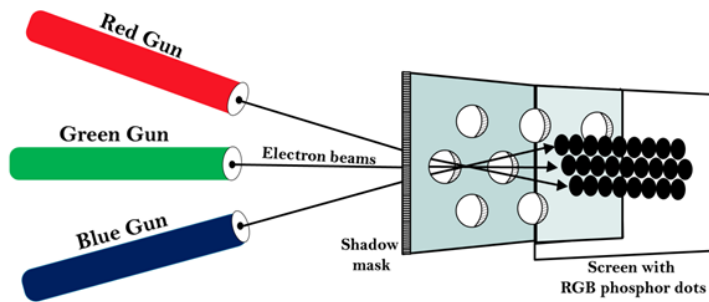
**Construction:** A shadow mask CRT has 3 phosphor color dots at each pixel position.

- 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.

Figure shows the delta-delta shadow mask method commonly used in color CRT system.



**The Shadow mask CRT**

**Working:** Triad arrangement of red, green, and blue guns.

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.

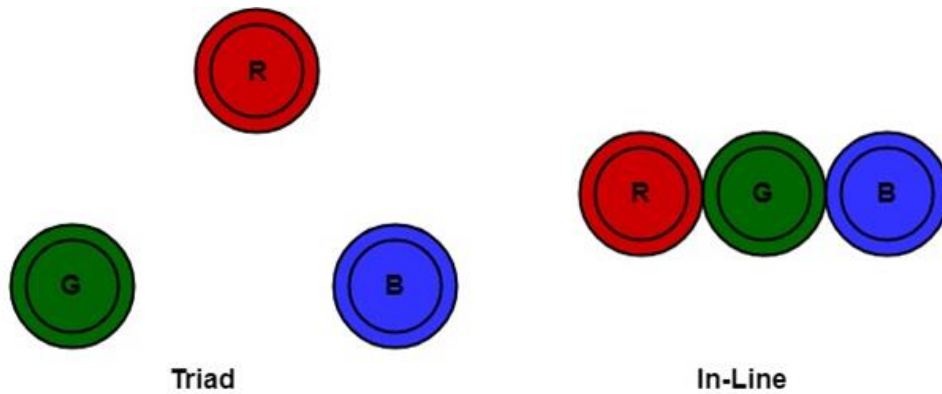
When the three beams pass through a hole in the shadow mask, they activate a dotted triangle, which occurs as a small color spot on the screen.

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.

**Inline arrangement:** Another configuration for the 3 electron guns is an Inline arrangement in which the 3

electron guns and the corresponding red-green-blue color dots on the screen, are aligned along one scan line rather than in a triangular pattern.

This inline arrangement of electron guns is easier to keep in alignment and is commonly used in high-resolution color CRT's.



**Fig: Triad and in-line arrangements of red, green and blue electron guns of CRT for color monitors.**

**Advantage:**

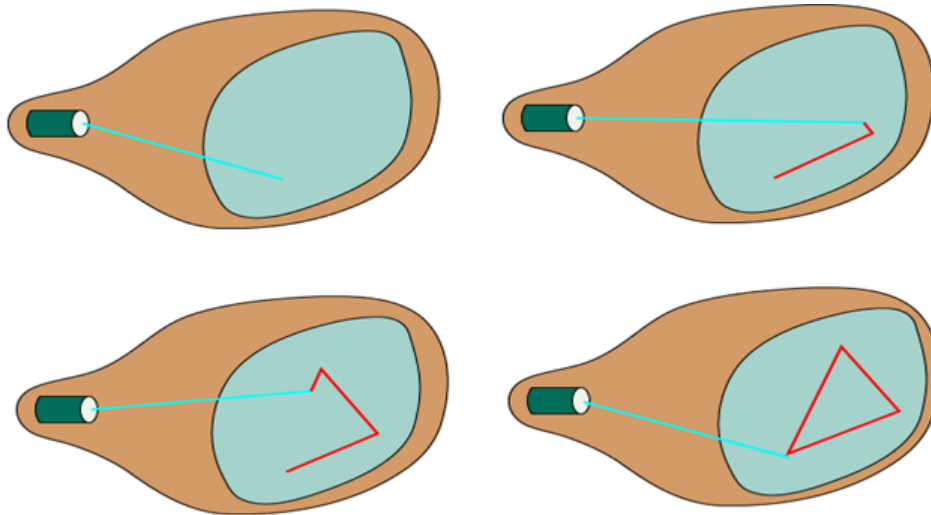
1. Realistic image
2. Million different colors to be generated
3. Shadow scenes are possible

**Disadvantage:**

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

**Random Scan and Raster Scan Display:**

Random Scan System uses an electron beam which operates like a pencil to create a line image on the CRT screen. The picture 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 the screen to the next, where its x & y coordinates define each point. After drawing the picture. The system cycles back to the first line and design all the lines of the image 30 to 60 time each second. The process is shown in fig:



Random-scan monitors are also known as vector displays or stroke-writing displays or calligraphic displays.

#### **Advantages:**

1. A CRT has the electron beam directed only to the parts of the screen where an image is to be drawn.
2. Produce smooth line drawings.
3. High Resolution

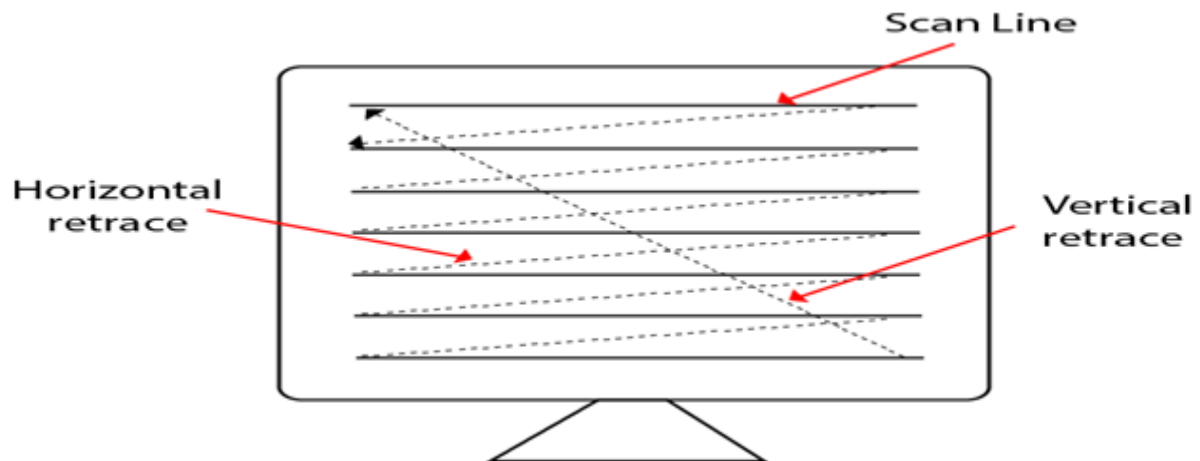
#### **Disadvantages:**

1. Random-Scan monitors cannot display realistic shades scenes.

#### **Raster Scan Display:**

A Raster Scan Display is based on intensity control of pixels in the form of a rectangular box called Raster on the screen. Information of on and off pixels is stored in refresh buffer or Frame buffer. Televisions in our house are based on Raster Scan Method. The raster scan system can store information of each pixel position, so it is suitable for realistic display of objects. Raster Scan provides a refresh rate of 60 to 80 frames per second.

Frame Buffer is also known as Raster or bit map. In Frame Buffer the positions are called picture elements or pixels. Beam refreshing is of two types. First is horizontal retracing and second is vertical retracing. When the beam starts from the top left corner and reaches the bottom right scale, it will again return to the top left side called at vertical retrace. Then it will again more horizontally from top to bottom call as horizontal retracing shown in fig:



### Types of Scanning or travelling of beam in Raster Scan

1. Interlaced Scanning
2. Non-Interlaced Scanning (**Progressive Scanning**)

### Difference between Interlaced Scan and Progressive Scan

Interlaced Scan and Progressive Scan are the formation scanning technique wide employed in analog video system.

#### Interlaced Scanning:

Interlaced Scanning takes place over dividing one frame. In interlaced scan, the displaying video speed is lesser than progressive scan. In interlaced scan, the video quality is vulgarized and there is present the combing effect in interlaced scan.



**Interlaced Scan**

#### Progressive Scanning:

Progressive Scanning takes place through scanning all frame promptly. In progressive scan, the displaying video speed is quicker than interlaced scan. In progressive scan, the video quality is superior than interlaced scan and there is not present combing effect in progressive scan.



### Progressive Scan

#### Advantages:

1. Realistic image
2. Million Different colors to be generated
3. Shadow Scenes are possible.

#### Disadvantages:

1. Low Resolution
2. Expensive

Let's see that the difference between interlaced scan and progressive scan which are given below:

S.NO	Interlaced Scan	Progressive Scan
1.	In interlaced scan, scanning takes place over dividing one frame.	While in progressive scan, scanning takes place through scanning all frame promptly.
2.	Interlaced scan is less efficient than progressive scan.	While progressive scan is more efficient than interlaced scan.
3.	In interlaced scan, the displaying video speed is lesser than progressive scan.	While in progressive scan, the displaying video speed is quicker than interlaced scan.
4.	There is present the combing effect in interlaced scan.	While there is not present combing effect in progressive scan.
5.	In interlaced scan, the video quality is vulgarized.	While in progressive scan, the video quality is superior than interlaced scan.

S.NO	Interlaced Scan	Progressive Scan
6.	Interlaced scan is less promoted than progressive scan.	While progressive scan is more promoted than interlaced scan.

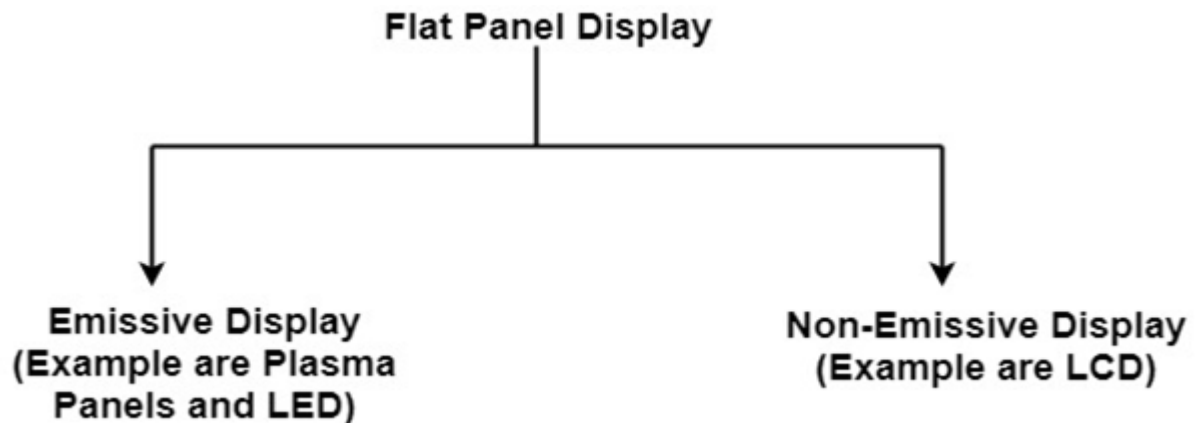
Differentiate between Random and Raster Scan Display:

Random Scan	Raster Scan
1. It has high Resolution	1. Its resolution is low.
2. It is more expensive	2. It is less expensive
3. Any modification if needed is easy	3.Modification is tough
4. Solid pattern is tough to fill	4.Solid pattern is easy to fill
5. Refresh rate depends on resolution	5. Refresh rate does not depend on the picture.
6. Only screen with view on an area is displayed.	6. Whole screen is scanned.
7. Beam Penetration technology come under it.	7. Shadow mark technology came under this.
8. It does not use interlacing method.	8. It uses interlacing
9. It is restricted to line drawing applications	9. It is suitable for realistic display.

### **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:

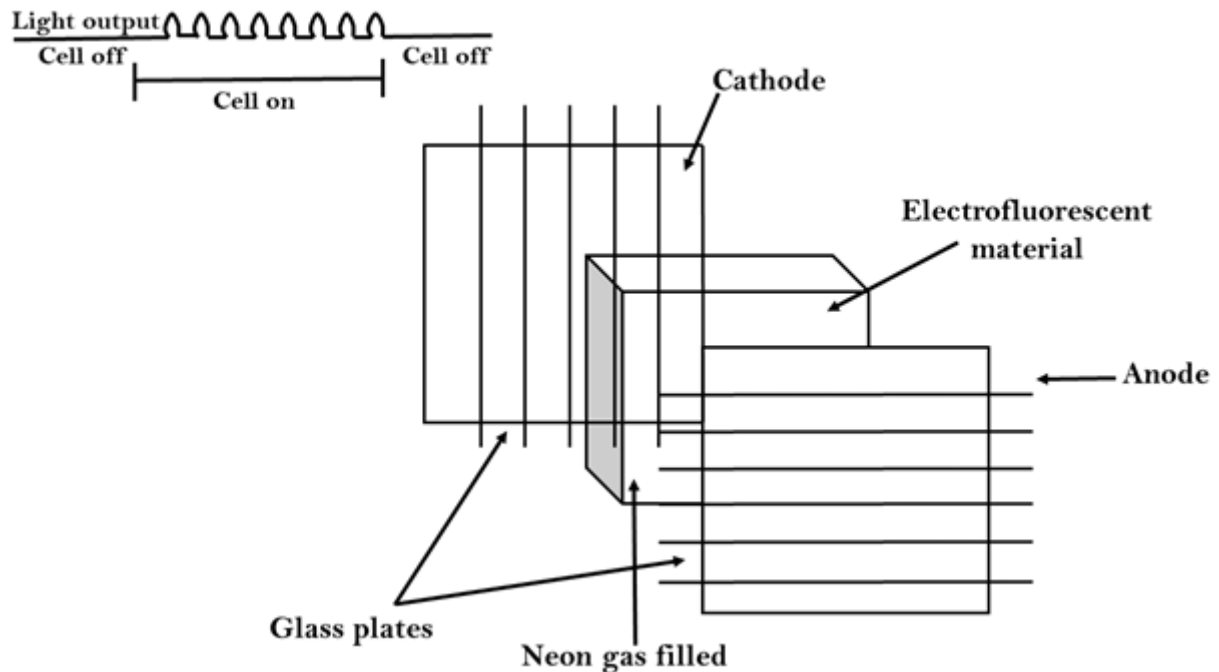
1. **Cathode:** It consists of fine wires. It delivers negative voltage to gas cells. The voltage is released along with the negative axis.
2. **Anode:** It also consists of fine wires. It delivers positive voltage. The voltage is supplied along positive axis.
3. **Fluorescent cells:** It consists of 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 flow 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.

**Figure shows the state of cell in plasma panel display:**



**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):**

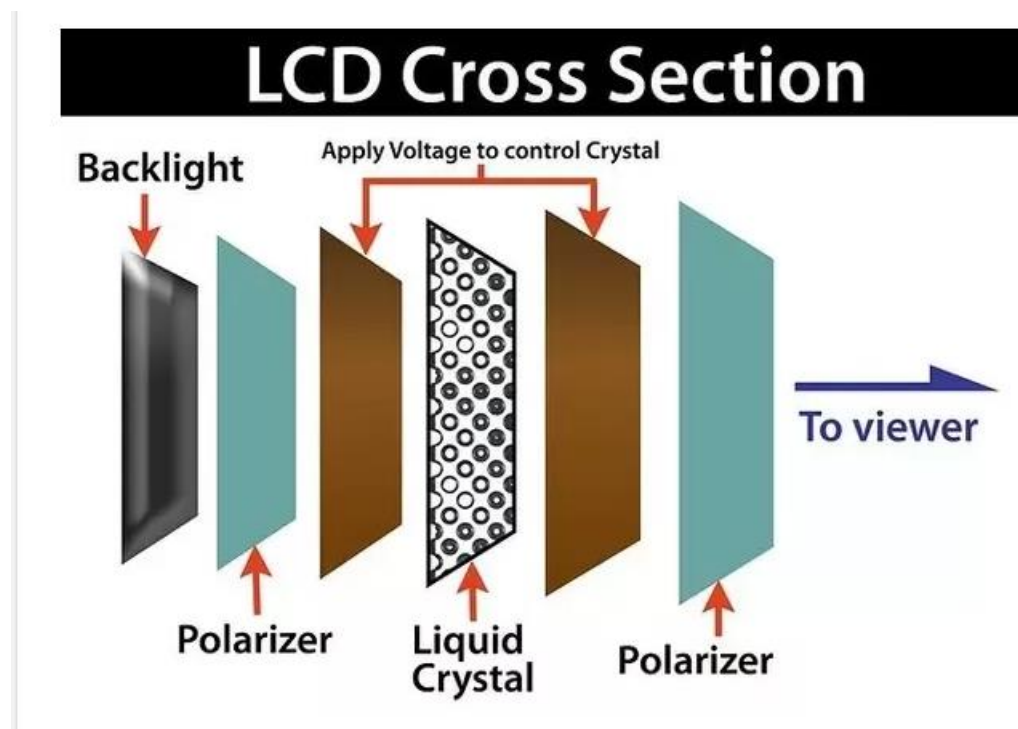
In an LED, a matrix of diodes is organized to form the pixel positions in the display and picture definition is stored in a refresh buffer. Data is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light pattern in the display.

### **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 (0 to 70) Celsius. It is flat and requires very little power to operate.



### **Explains Liquid Crystal Display Monitor**

Various different LCD technologies are used today, including:

- **In Plane Switching (IPS) Panel Technology:** These panels are considered to have the best color accuracy, viewing angles and image quality in LCD technology.
- **Super Plane to Line Switching (PLS):** Developed by Samsung, this LCD panel is very similar to the IPS panel but reportedly, it is 10 percent brighter, has wider viewing angles and is cheaper to produce.
- **Vertical Alignment (VA) Panel Technology:** These panels are considered to be in the middle of TN and IPS technology. Compared to TN panels, they offer wider viewing angles and better color quality but have slower response times. They have higher contrast ratios, compared to the other panels but have a downside, in terms of color shifting, where the brightness display is unevenly distributed throughout the screen.
- **Twisted Nematic (TN) Panel Technology:** These panels are the most commonly used type of panel in LCD technology. They are cheaper and offer faster response times, making them a preferred choice for gamers. The downside is that the viewing angles, contrast ratios and color production are considered the lowest of LCD panel types.

#### **Advantages of LCD :**

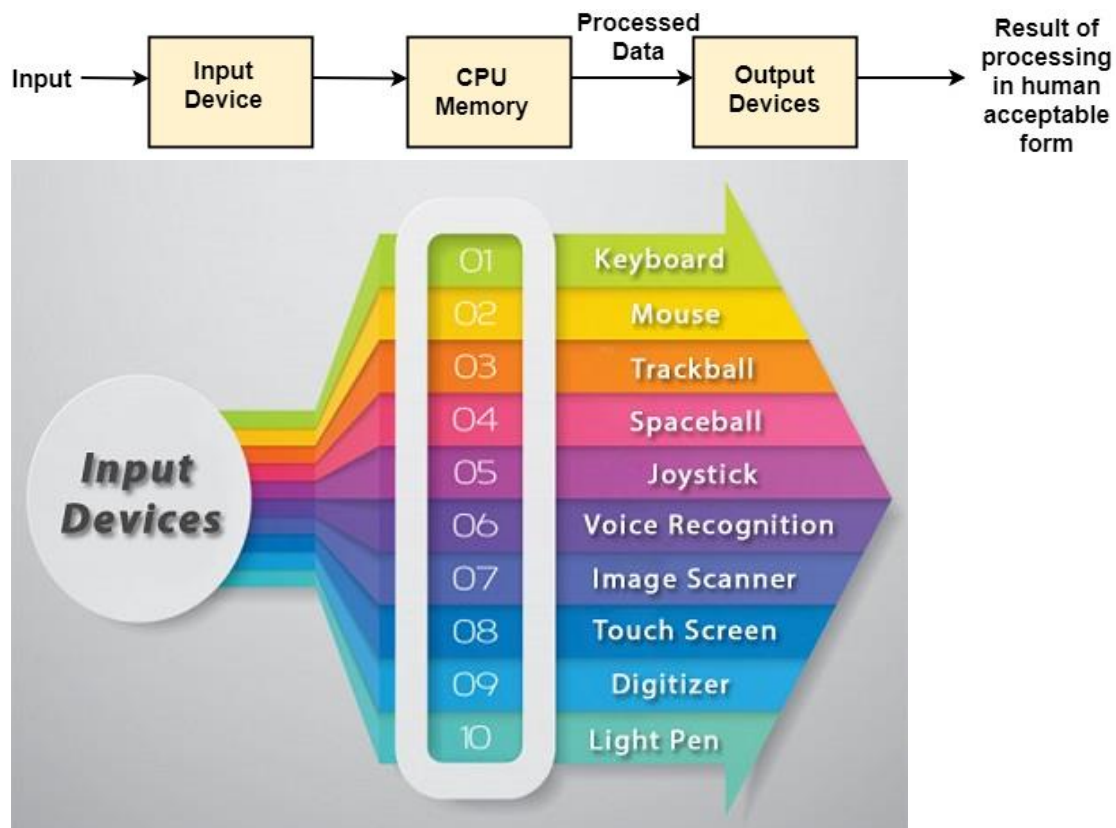
- The main advantage of LCD is, it has low in cost and energy efficient and very less power consumption.
- LCD is thinner and lighter and very flexible.
- LCD provides excellent contrast, brightness and resolution, so the picture quality is very clear like a crystal.
- Radiation of LCD monitors are much less than CRT monitors.
- LCDs can be suitable with [CMOS](#) integrated circuits so that making of LCD is very easy.
- It gives perfect sharpness at the native resolution.
- Zero geometric distortion at the native resolution of the pane.
- It provides various conveniences like portability as compared to previous technology based screens.

#### **Disadvantages of LCD**

- LCD require additional light sources for lighting the pixels, so if the light source is destroyed then the LCD is not providing any image on the display.
- LCD is less reliable display.
- The image visibility depends on light intensity
- The aspect ratio and resolution are fixed for LCD.
- LCD has an irregular intensity scale and it produce lower than 256 discrete intensity levels.
- In LCD color saturation is reduced at the low intensity level due to poor black-level.
- LCD provide limited viewing angle, it effects the brightness. if we are watching the screen by an angle then the color of the image is changed in our eyes.

#### **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.



### 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.

### **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.

### **Advantage:**

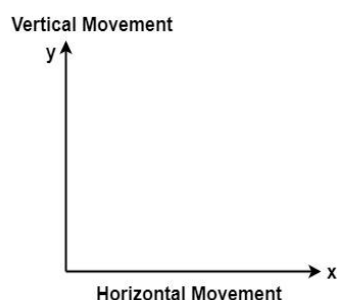
1. Suitable for entering numeric data.
2. Function keys are a fast and effective method of using commands, with fewer errors.

### **Disadvantage:**

1. Keyboard is not suitable for graphics input.

### **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.

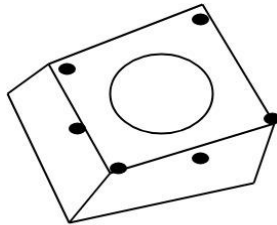


### **Advantage:**

1. Easy to use
2. Not very expensive

## 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.



TrackBall

### Advantage:

1. Trackball is stationary, so it does not require much space to use it.
2. Compact Size

### Spaceball:

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 its 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.



Joystick

## 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:

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.



Digitizer

**Advantages:**

1. Drawing can easily be changed.
2. It provides the capability of interactive graphics.

**Disadvantages:**

1. Costly
2. Suitable only for applications which required high-resolution graphics.

**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.

**Advantage:**

1. More efficient device.
2. Easy to use
3. Unauthorized speakers can be identified

**Disadvantages:**

1. Very limited vocabulary
2. Voice of different operators can't be distinguished.