Computer Graphics and Multimedia.

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Introduction to Computer Graphics

Computer graphics is a rapidly evolving field. until the past two decades graphics was mainly a realm of artist. now, computer graphics has touched the lives of not only artist and Engineers but also the common man in various ways.

Buy graphics we will refer to any sketch, drawing, special artwork or other materials to pictorially depict an object or process or otherwise convey information, as a supplement to or instead of written description.

Introduction cont.

In computer graphics, pictures or graphic objects are represented as a collection of discrete picture elements called *pixels* ***(picture element).***

The pixel is the smallest addressable screen elements. it is the smallest piece of display screen which we can control. The control is achieved by setting the intensity and colour of the pixel which compose the screen.

Advantages of Computer Graphics

The advantages of computer graphics are as follows;

1. It provides tools for producing pictures not only of concrete real-world object but also of abstract, synthetic object such as mathematical surfaces in 4D and of data that have no inherent geometry such as Survey results.

2. It has the ability to show moving pictures and thought it is possible to produce animation with computer graphics.

3. With computer graphics users can also control the animation speed, portion of the view and goniometric relationship of the object in the scene to one another and the amount of detail shown.

4. Computer graphics provide tools called **motion dynamics**. With this, the user can move and tumble object with respect to stationary observer, or he can make an object stationary and the viewer moves around them. A typical example is walk through made by builders to show flat interior and building surroundings. in many cases it is possible to move both objects and viewer.

5. Computer graphics also provides facility called ***update dynamics***. With update dynamics it is possible to change the shape colour or other properties of the objects being viewed.

6. With the recent development of ***digital signal processing*** and audio synthesis chip the interactive graphics can now provide audio feedback along with the graphical feedback to make the simulated environment even more realistic.

Application Areas of Comp. Graphics

Today, computer graphics is used in a variety of Fields ranging from routine everyday activities to very specialised area in widely different fields, including business, engineering, medicine, government, education, training, advertising research, art and entertainment and communication in general.

Some of the major application area are listed below;

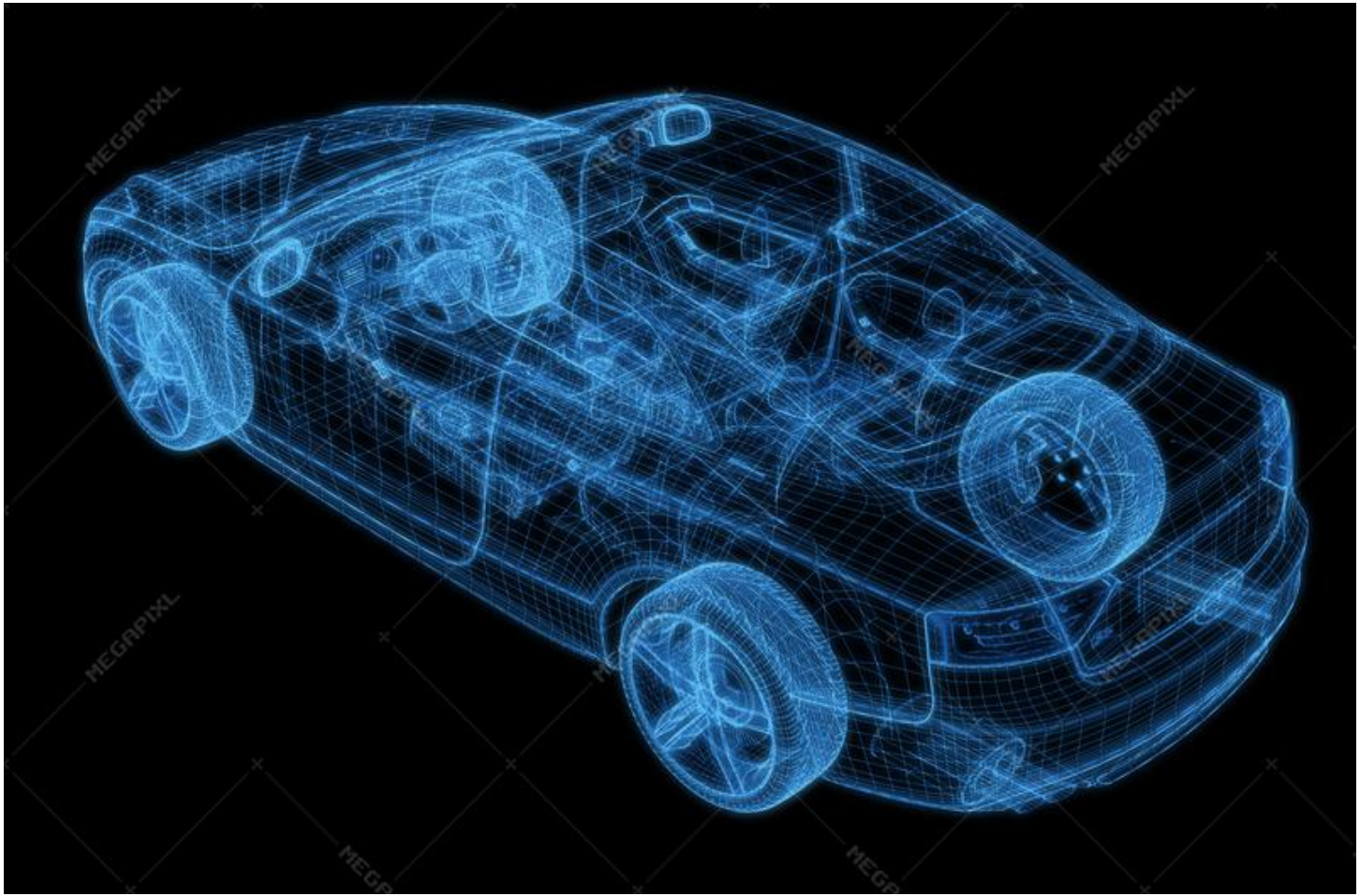
Computer Aided Design/Drafting (CAD/CADD)

A major use of computer graphics is in design process, particularly for engineering applications such as building and other structural design, mechanical and industrial design as well as design of manufacturing processes, including that of automobiles and aircraft, ships and spacecrafts and many other products.

For some design applications, objects are first displayed in a wireframe outline form that shows the overall shape and the internal features of the objects. ***Wireframe*** display also allows designers to quickly see the effect of interactive adjustment to design shapes.

Current computer aided design (CAD) software packages range from 2D vector based drafting systems to 3D solid and surface modellers.

Modern CAD applications can also frequently allow rotation in 3D allowing viewing of designed objects from a desired angle, even from the inside looking out. Some CAD software is capable of dynamic mathematical modelling in which case it may be marketed as CADD (Computer Aided Design and Drafting).



Presentation Graphics

Presentation refers to the act of presenting important points of a topic to;
a. the audience for a lecture,
b. potential customers for a new product or service.

The presentation of data in a condensed, visual, convenient form has always been an aid to understanding and promoting any idea. Graphics becomes a vital part of presenting ideas and promoting organisations even in non business endeavours such as at academic seminars or for proposing a new construction and so on. Computer graphics has raised such presentations to an art by making visuals more appealing colourful by incorporating animations, sound effects, videos in presentations.

Entertainment

Computer graphics methods are used in making music videos games cartoon movies television shows etc. Sometimes the graphic scenes are displayed by themselves and sometimes graphic objects are combined with the actors and live scenes Several developers have used graphics sound animation of multimedia to create variety of games.

Computer-Aided Learning

Computer generated models of physical financial and economic system are used as educational aids. Needless to say, computer graphics tools like MS Power Point are used heavily in teaching, seminars and conference presentations on almost every subject at every level.

Classification of Computer Graphics

Computer graphics can be classified into two main categories, according to the application areas. They are passive and interactive graphics.

1. **Passive (off-line) computer graphics**: The most common example of passive computer graphics is a static website, where users have no control over the contents on the monitor.
2. **Interactive computer graphics**: This is called interactive graphics. Displays are controlled by mouse, trackball, joystick etc. Video Games, dynamic websites, special effects in movies and cartoons are all making use of interactive computer graphics.

Components of Interactive Computer Graphics system.

Interactive computer graphics consists of three components such as;

1. Digital Memory buffer
2. Monitor
3. Display controller

Using these components, we are able to see the output on the screen in the form of pixels

Digital Memory Buffer

This is a place where images and pictures are stored as an array (matrix of 0 & 1, 0 represents darkness and 1 represents image or picture).

Frame buffer is the video RAM (V-RAM) that is used to hold or map the images displayed on the screen

$$\text{Memory in MB} = \frac{(\text{X-resolution} \times \text{Y-resolution} \times \text{Bits per pixel})}{8 \times 1024 \times 1024}$$

Monitor

Monitor helps us to view the display and they make use of CRT technology (Cathode ray Tube).

Display Controller

It is an interface between Memory Buffer and Monitor. Its job is to pass the contents of frame buffer to the monitor. The image must be passed repeatedly to the monitor to maintain a steady picture on the screen.
The display controller reads each successive byte of data from FB Memory and converts 0's and 1's into corresponding video signals. This signal is then feed to the monitor to produce a black and white picture on screen. In today's term, display controller is recognized as a **display card** and one of our choices can be VGA card with a resolution of 640x480.

Computer Vision

Computer vision is the field of computer science that focuses on creating digital systems that can process, analyze, and make sense of visual data (images or videos) in the same way that humans do.

The concept of computer vision is based on teaching computers to process an image at a pixel level and understand it. Technically, machines attempt to retrieve visual information, handle it, and interpret results.
The primary goals of computer vision include:

1. Detection, segmentation, location and recognition of certain objects in an image.
2. Tracking an object through image sequence.
3. Mapping a scene to a 3D model of the scene.

Computer Vision

These goals are achieved by means of pattern recognition, statistical learning, image processing, graph theory and other related fields. Cognitive computer vision is strongly related to cognitive psychology and biological computation.

One interesting application of computer vision, commonly used in creation of visual effects for cinema and broadcast, is *camera tracking*. Computer Vision also finds its application in medicine, military,industry, security, quality inspection, robotics and many other Fields

Image Processing

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

Image processing basically includes the following three steps:

1. Importing the image via image acquisition tools;
2. Analysing and manipulating the image;
3. Output in which result can be altered image or report that is based on image analysis.

Graphics Primitives.

The interactive devices are the devices that give input to the graphics system and provides necessary feedback to the user about the accepted input.

Various devices are available for input on a graphics workstation.

Keyboard

A **computer keyboard** is an input device used to enter characters and functions into the computer system by pressing buttons, or **keys**.

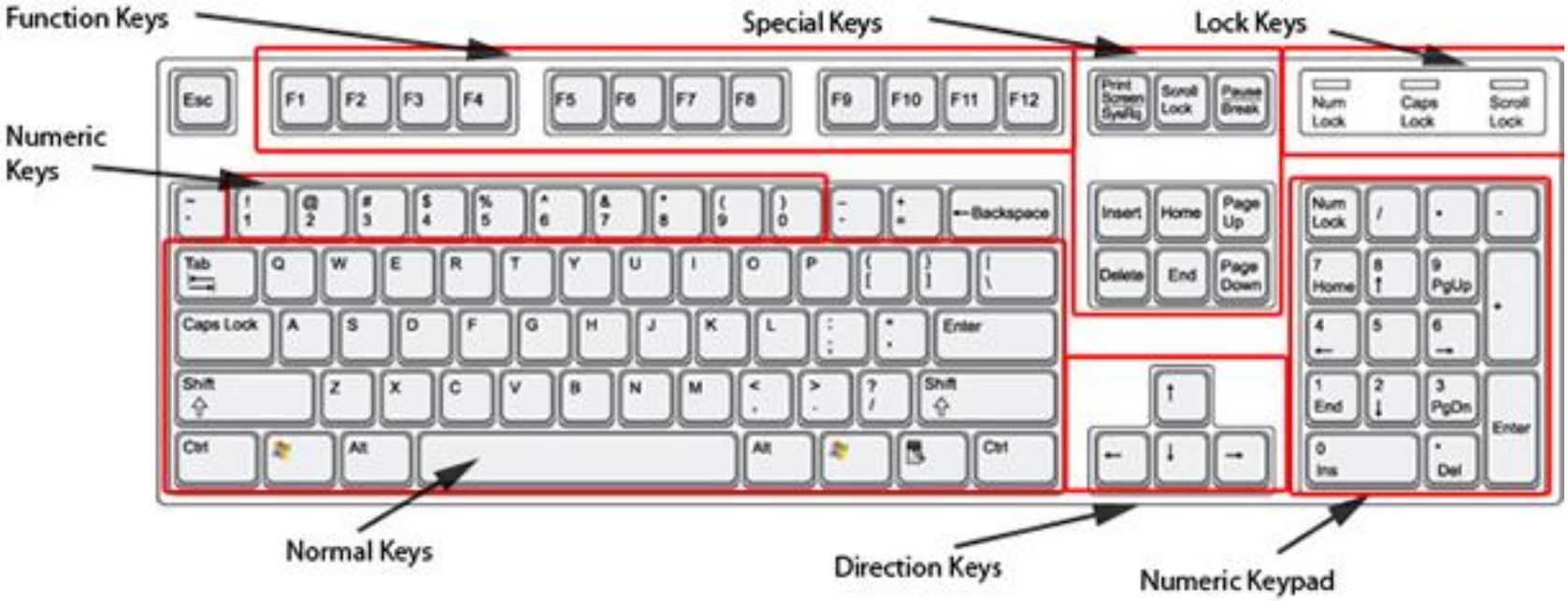
It is the primary device used to enter text. A keyboard typically contains keys for individual letters, numbers and special characters, as well as keys for specific functions, it is connected to a computer system using a cable or a wireless connection.

Standard Keyboard

The number of keys on a keyboard varies from the original standard of 101 keys to the 104-key windows keyboard.

There are five parts of a standard keyboard;

1. The Alphanumeric Keys
2. The numeric keypad
3. Function keys
4. Modifier keys
5. Cursor movement keys.


Function Keys
Special Keys
Lock Keys
Numeric Keys
Esc
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
F11
F12
Print Screen SysRq
Scroll Lock
Pause Break
Num Lock
Caps Lock
Scroll Lock
Backspace
Tab
Caps Lock
Enter
Shift
Ctrl
Alt
Insert
Home
Page Up
Delete
End
Page Down
Num Lock
7 Home
8
9 PgUp
4
5
6
1 End
2
3 PgDn
0 Ins
Del
Enter
Normal Keys
Direction Keys
Numeric Keypad

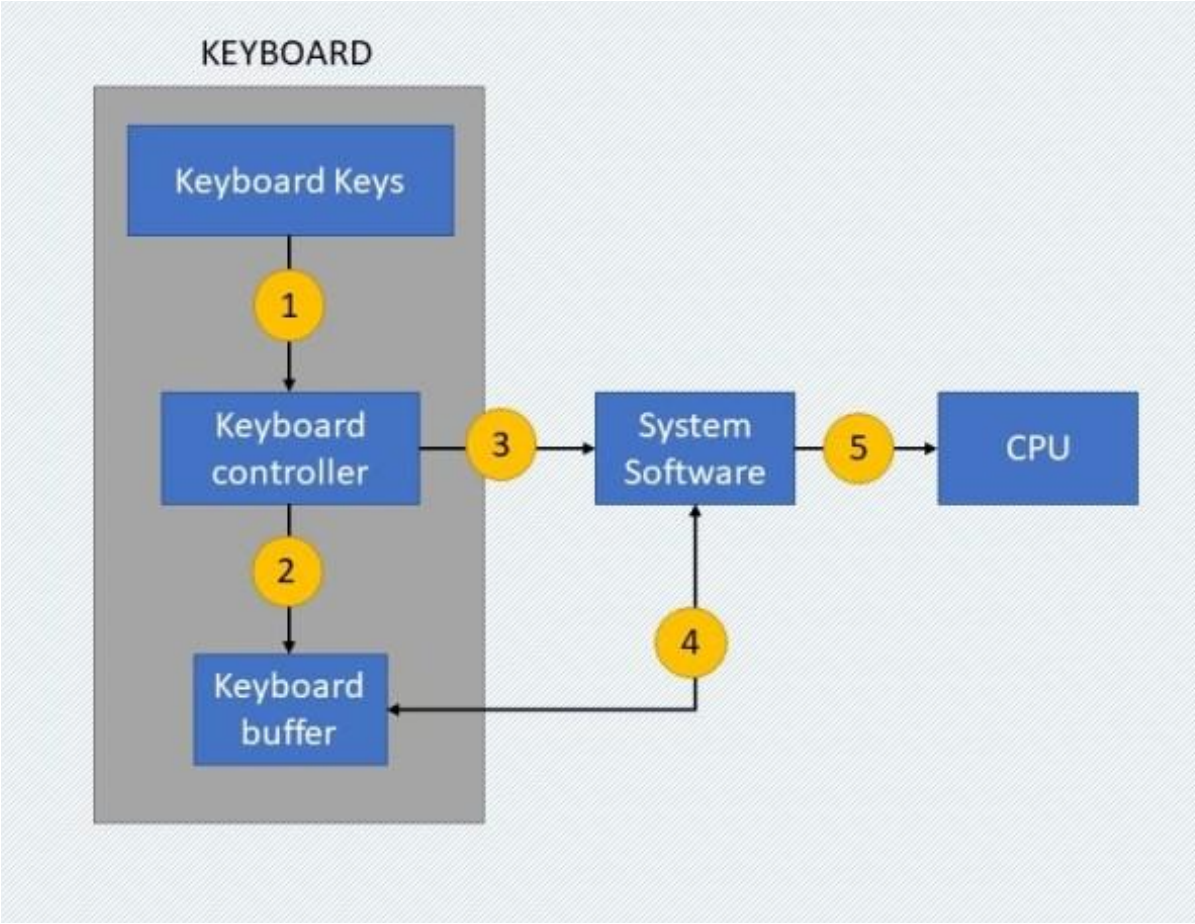
How Computer Accepts Inputs From Keyboard.

When we press a key, a tiny chip in the keyboard called **keyboard controller** notes that a key has been pressed. The keyboard controller places a code (**Key Scan**) in the buffer of the keyboard to indicate which key was pressed (**Keyboard buffer** is a temporary memory of the keyboard controller).

The keyboard controller sends a signal to the system software notifying that something happened at the keyboard.

How Computer Accepts Inputs From Keyboard.

When the system receives the signal it determines the appropriate response. When a keystroke has occurred, the system reads the memory location in the keyboard buffer that contains the code of the key which was pressed. The system software then passes that code to the CPU.


KEYBOARD
Keyboard Keys
1
Keyboard controller
2
Keyboard buffer
3
System Software
4
5
CPU

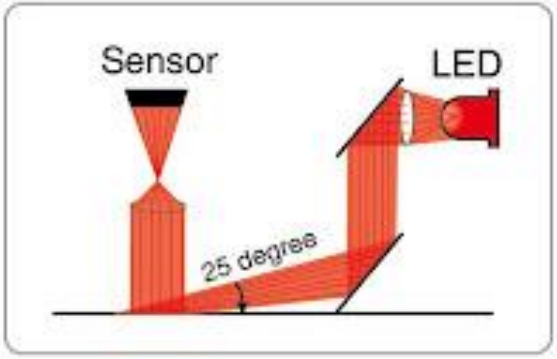
The Mouse

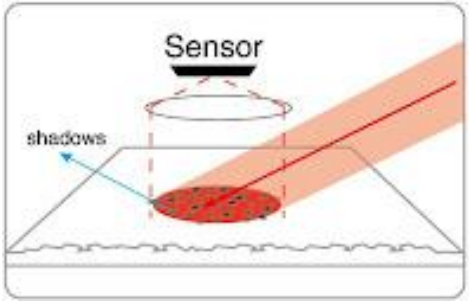
A computer mouse is a handheld hardware input device that controls a cursor in a GUI (graphical user interface) for pointing, moving and selecting text, icons, files, and folders on your computer.

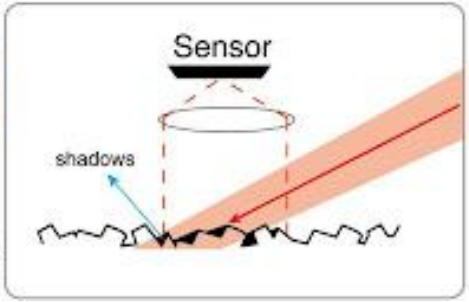
In addition to these functions, a mouse can also be used to drag-and-drop objects and give you access to the right-click menu.

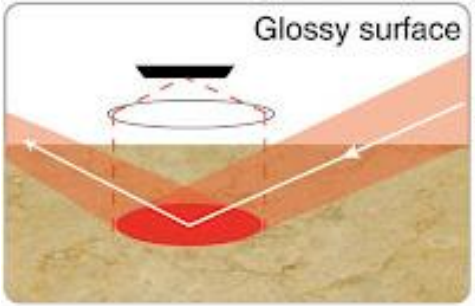
The two types of mouse are the (Mechanical and Optical mouse).

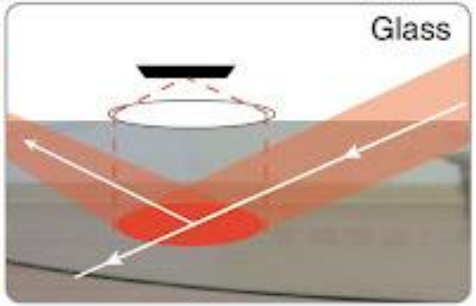

Regular Optical engine


Sensor
LED
25 degree


Sensor
shadows


Sensor
shadows


Glossy surface


Glass

Trackball

Spaceball

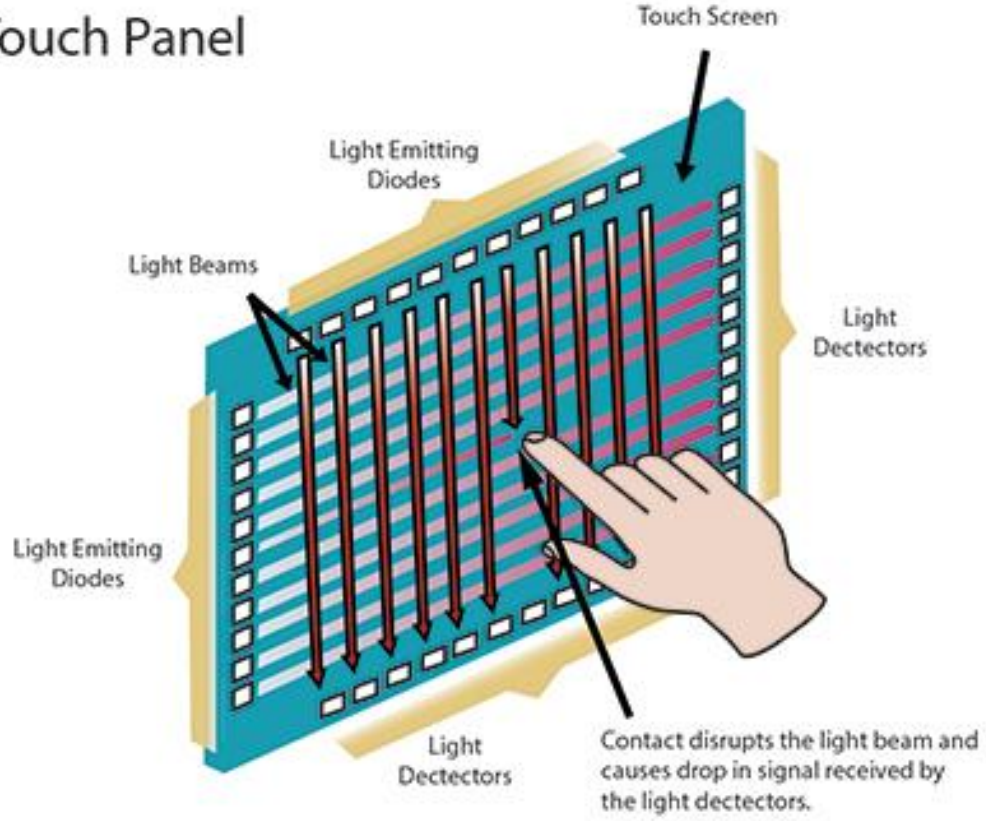
Other pointing device are; touchpad and Joystick.

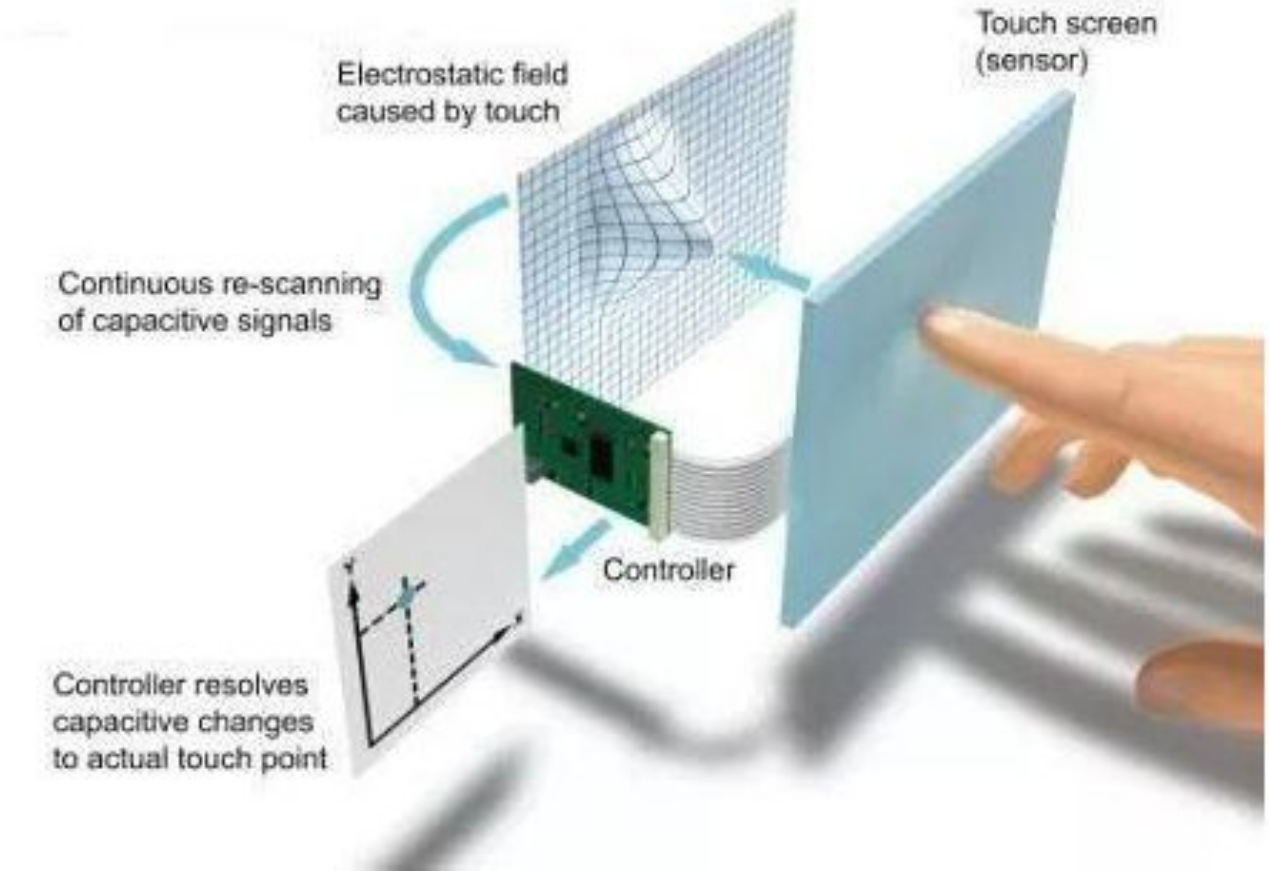
Touch-Screen

A touch screen is a display device that allows the user to interact with a computer using their finger or stylus.

They're a useful alternative to a mouse or keyboard for navigating a GUI (graphical user interface). Touch screens are used on a variety of devices, such as a computer and laptop displays, smartphones, tablets, cash registers, and information kiosks.

Infrared Touch Panel




Touch screen
(sensor)
Electrostatic field
caused by touch
Continuous re-scanning
of capacitive signals
Controller
Controller resolves
capacitive changes
to actual touch point

Digitizers and Graphic Tablets

A graphics tablet (digitizer, digital graphic tablet, pen tablet, or digital art board) is an input device that enables a user to hand-draw images, animations and graphics, with a special pen-like stylus, similar to the way a person draws images with a pencil and paper.

These tablets may also be used to capture data or handwritten signatures. It can also be used to trace an image from a piece of paper that is taped or otherwise secured to the tablet surface. Capturing data in this way, by tracing or entering the corners of linear polylines or shapes, is called digitizing.

Output Devices

Monitor display is good for the creation, checking and modification of images.

Hardcopy in the form of printed or plotted output on paper is also a necessity for some use cases.

Printer

A printer is a device that accepts text and graphic output from a computer and transfers the information to paper, usually to standard-size, 8.5" by 11" sheets of paper.

Printers vary in size, speed, sophistication and cost. In general, more expensive printers are used for more frequent printing or high-resolution color printing.

The major printer technologies available. These technology can be broken down into two main categories(Impact and Non-impact)

Display Devices

The most important part of a PC is the display system. The display systems is where the graphics are rendered in the screen of the computer. It is responsible for graphic display.

Some of the common types of display systems are;

1. Random Scan display
2. Raster Scan display
3. Direct View storage tube
4. Flat Panel display

Display Devices

Display systems has 3 parts;

1. Display Adapter: Creates or holds the color information
2. Monitor: Display the information
3. Cable: Carries the information between the display adapter and monitor.

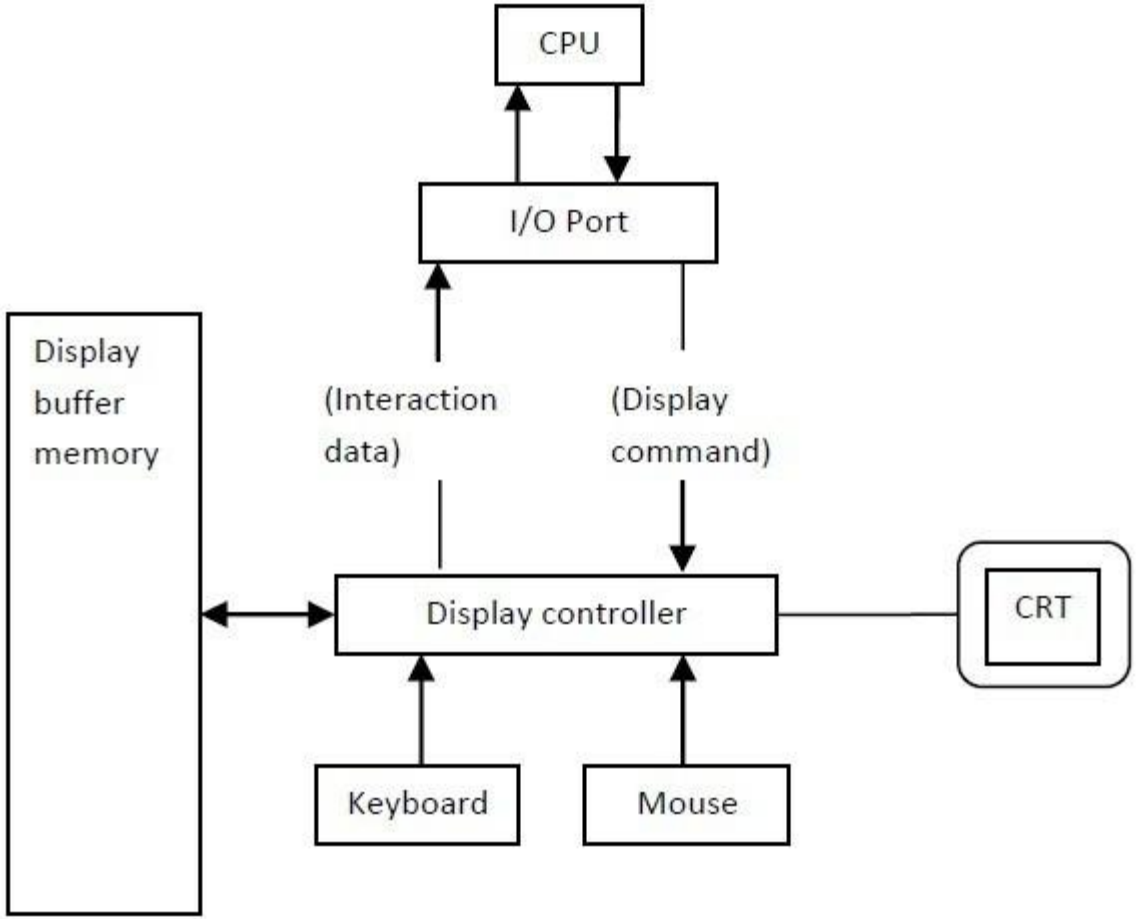
Random Scan Display

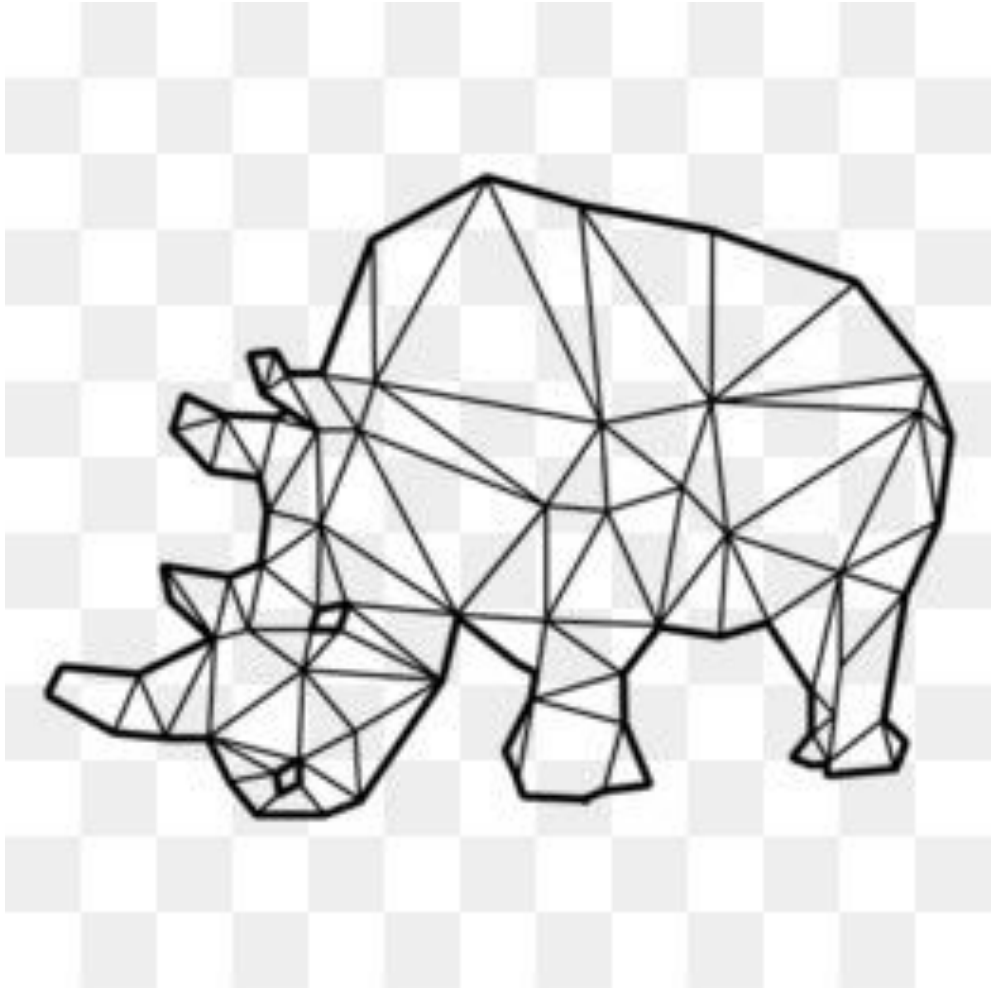
In Random-Scan Display electron beam is directed only to the areas of screen where a picture has to be drawn. It is also called ***vector display***, as it draws picture one line at time. It can draw and refresh component lines of a picture in any specified sequence. Pen plotter is an example of random-scan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

The number of lines regulates refresh rate on random-scan displays. An area of memory called refresh display files stores picture definition as a set of line drawing commands.

Random Scan Display

The system returns back to first-line command in the list, after all the drawing commands have been processed. High-quality vector systems can handle around 100, 00 short lines at this refresh rate. Faster refreshing can burn phosphor. To avoid this every refresh cycle is delayed to prevent refresh rate greater than 60 frames per second.


CPU
I/O Port
Display buffer memory
(Interaction data)
(Display command)
Display controller
CRT
Keyboard
Mouse



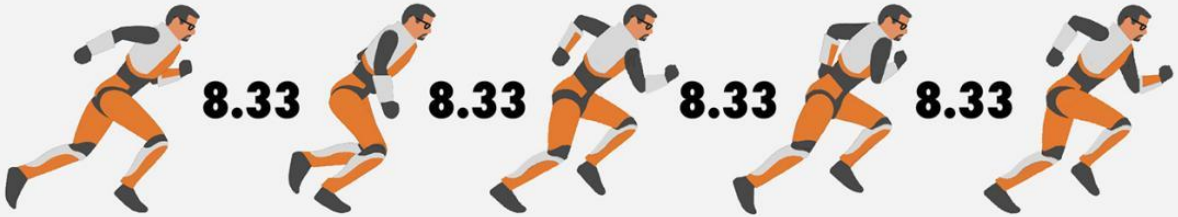
Refresh Rate

Refresh rate refers to the frequency that a display updates the onscreen image. The time between these updates is measured in milliseconds (ms), while the refresh rate of the display is measured in hertz (Hz).

The refresh rate of your display refers to how many times per second the display is able to draw a new image. This is measured in Hertz (Hz).

Refresh Rate

For example, if your display has a refresh rate of 144Hz, it is refreshing the image 144 times per second. When paired with the high frame rates produced by a GPU and CPU working together, this can result in a smoother experience and potentially higher FPS.

120 Hz  8.33 8.33 8.33 8.33

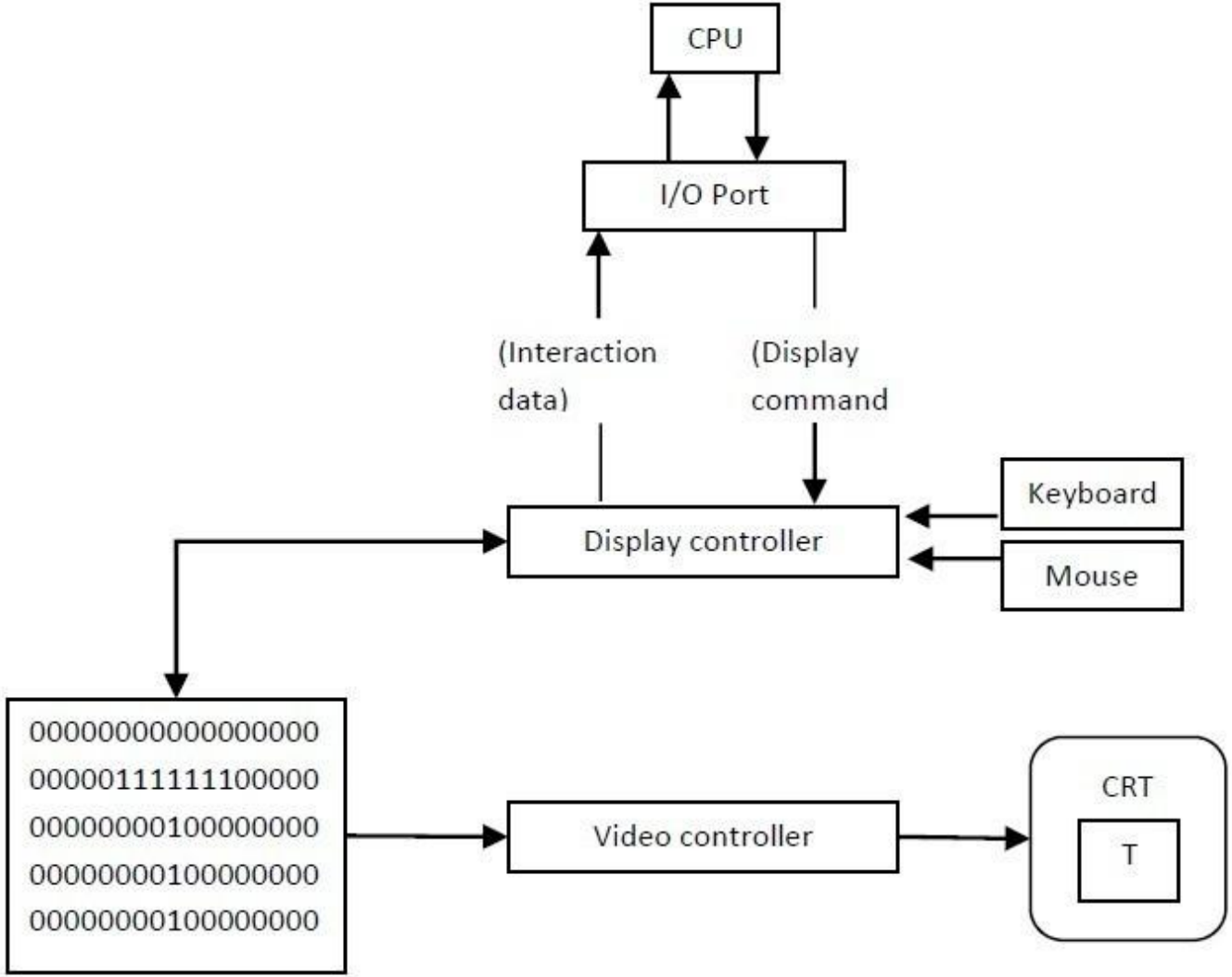
60 Hz  16.67 16.67

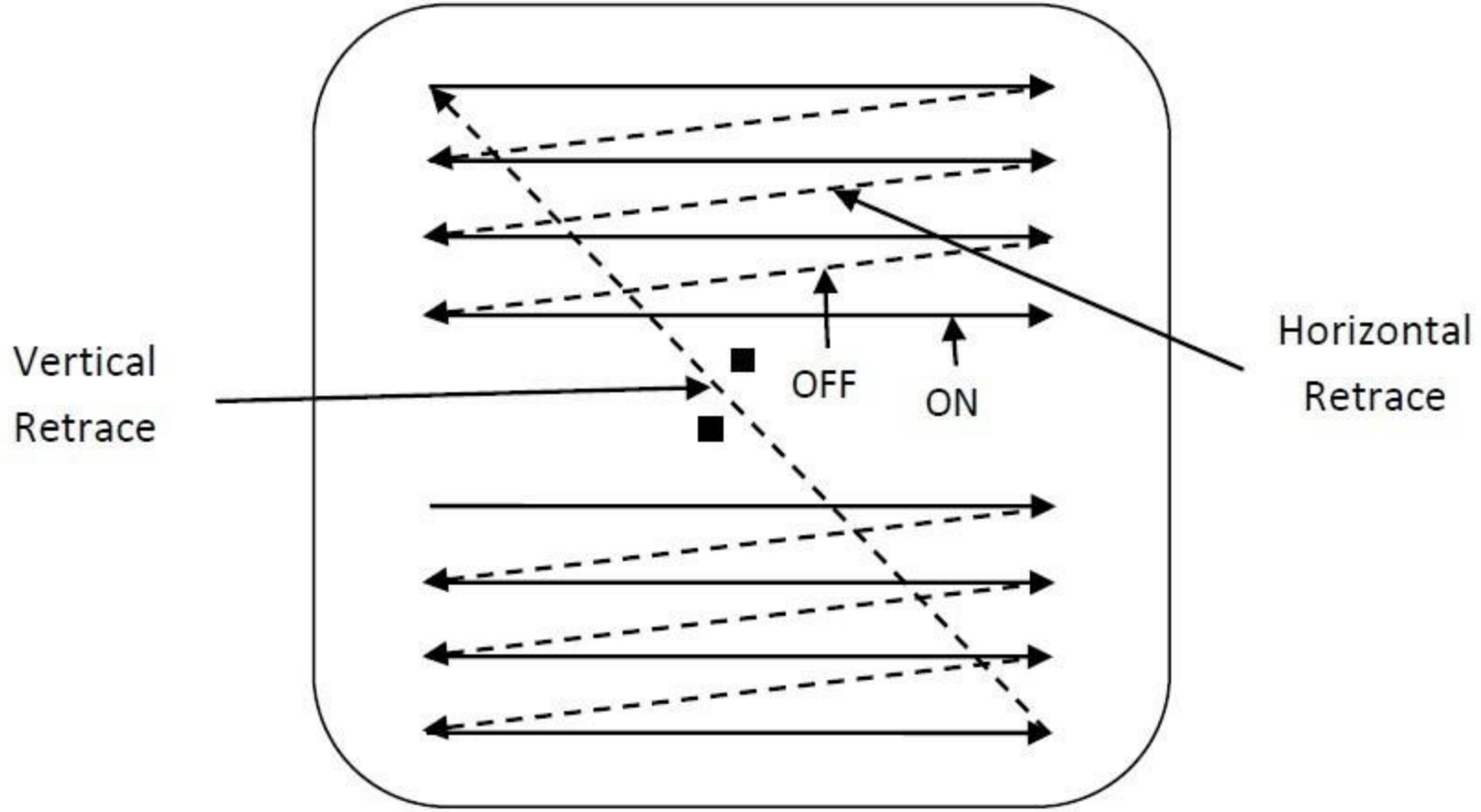
30 Hz  33.33

Raster scan display

Raster Scan Displays are most common type of graphics monitor which employs CRT. It is based on television technology. In raster scan system electron beam sweeps across the screen, from top to bottom covering one row at a time.

A pattern of illuminated pattern of spots is created by turning beam intensity on and off as it moves across each row. A memory area called ***refresh buffer or frame buffer*** stores picture definition. This memory area holds intensity values for all screen points. Stored intensity values are restored from frame buffer and painted on screen taking one row at a time. Each screen point is referred to as pixels.


CPU
I/O Port
(Interaction data)
(Display command
Keyboard
Display controller
Mouse
00000000000000000
00000111111100000
00000000100000000
00000000100000000
00000000100000000
Video controller
CRT
T


Vertical
Retrace
OFF
ON
Horizontal
Retrace

Direct-View Storage Tube (DVST)

Both in the raster scan and random scan system, the screen images are maintained (flicker free) by redrawing or refreshing the screen many times per second by cycling through the picture data stored in the refresh buffer.

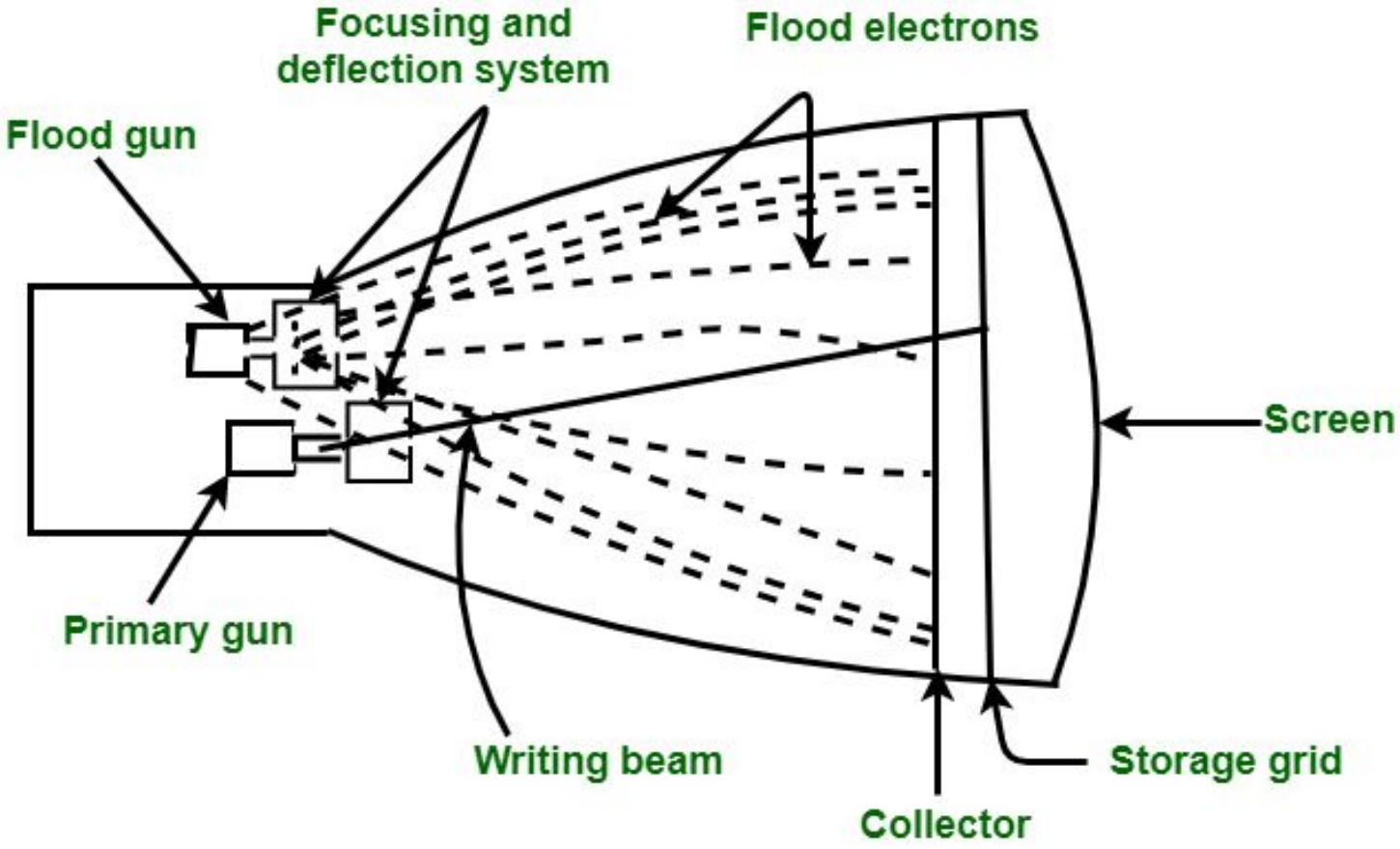
A DVST gives the alternative method of maintaining the screen image, it uses the storage grid which stores the picture information as a charge distribution just behind the phosphor-coated screen. It consists of two electron guns:

1. Primary gun
2. Flood gun

Direct-View Storage Tube (DVST)

The primary gun store stores the picture pattern and the flood gun maintains the picture display.

DVST resembles CRT as it uses electron gun to draw picture and phosphor coated screen to display it. The phosphor used in this is of high persistence. DVST does not use refresh buffer or frame buffer to store picture definition. Picture definition is stored inside CRT in form positive charged distribution.
Because of this reason DVST is known as ***Storage Type CRT***. In DVST no refreshing is required as result picture drawn on DVST will be seen for several minutes before fading.


Focusing and
deflection system
Flood electrons
Flood gun
Screen
Primary gun
Writing beam
Storage grid
Collector

Flat Panel Display

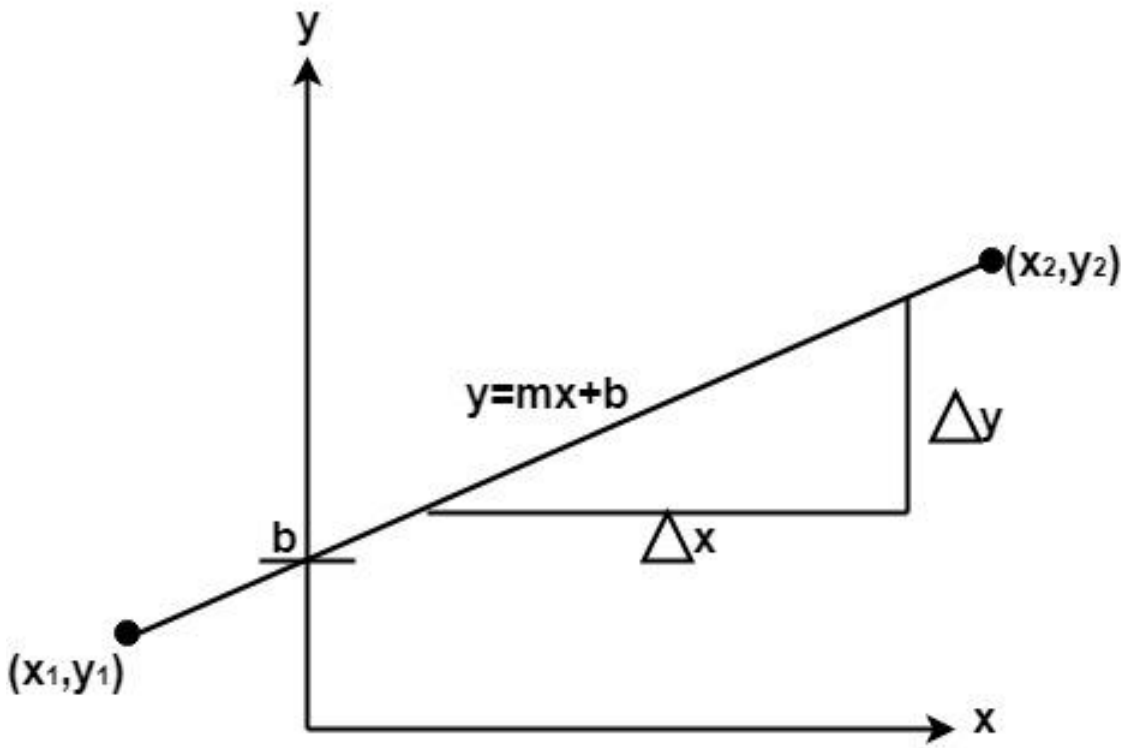
A flat panel display is a television, monitor or other display device that uses a thin panel design instead of a traditional cathode ray tube (CRT) design. These screens are much lighter and thinner, and can be much more portable than traditional televisions and monitors. They also have higher resolution than older models.

Examples of flat panel display are: Liquid crystal display (LCD), Gas plasma display (GPD) and Electroluminescent display (ELD)

Scan Conversion

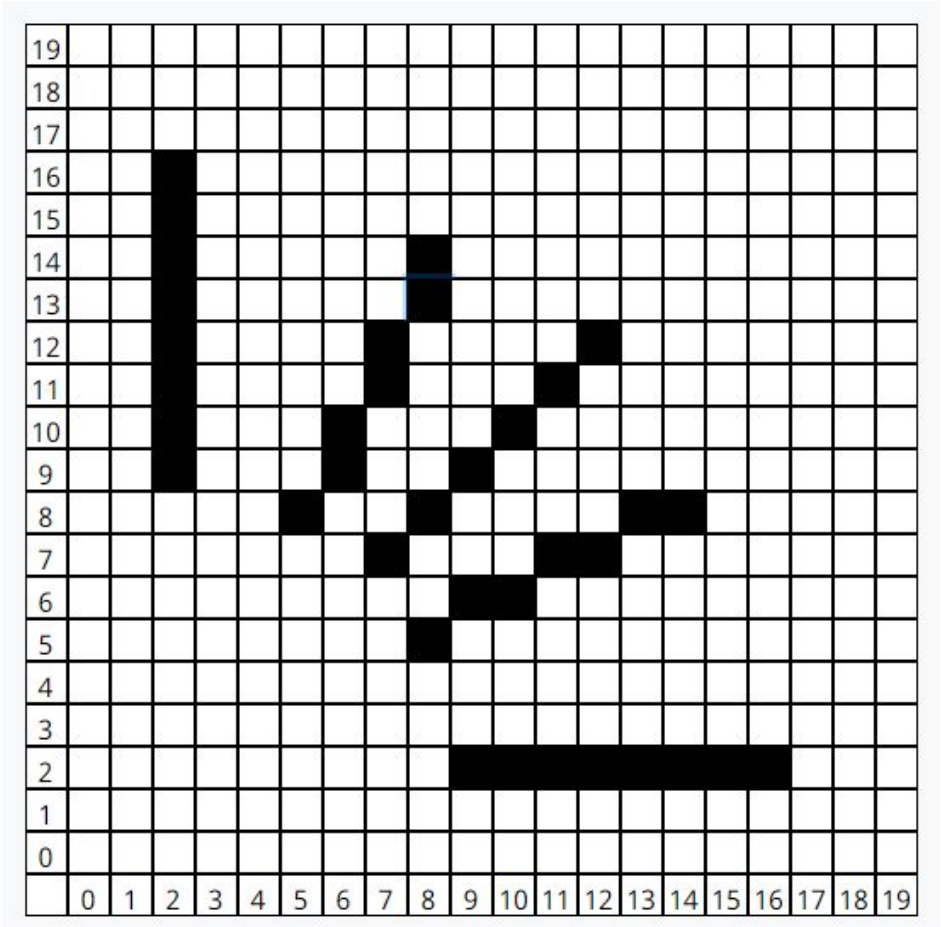
A straight line may be defined by two endpoints and an equation. The two endpoints are described by points ***(x1,y1)*** and ***(x2,y2)***. The equation of the line is used to determine the x, y coordinates of all the points that lie between these two endpoints.

Scan Conversion



Scan Conversion

Using the equation of a straight line, ***y = mx + b*** where ***m*** = slope of a line and ***b*** = the y intercept, we can find values of y by incrementing x from x =x1, to x = x2. By scan-converting these calculated x, y values, we represent the line as a sequence of pixels.


19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Vector Generation

Vector images are graphical representations of mathematical objects such as lines, curves, and polygons. These graphics are generated by computer and they follow x and y axis as their reference definition.

The process of “turning on” the pixels for a line segment is called Vector Generation.
The following are characteristics of a line:

1. The line should appear as a straight line and it should start and end accurately.
2. The line should have equal brightness throughout their length
3. The line should be drawn rapidly.

Digital Differential Analyzer (DDA) Algorithm

In any 2-Dimensional plane if we connect two points (x0, y0) and (x1, y1), we get a line segment.

But in the case of computer graphics, we can not directly join any two coordinate points, for that we should calculate intermediate points coordinates and put a pixel for each intermediate point, of the desired color with help of functions.

Digital Differential Analyzer (DDA) Algorithm

Step 1 – Get the input of two endpoints *(X0,Y0)* and *(X1,Y1).*

Step 2 – Calculate the difference between two endpoints.

dx = X1 - X0

dy = Y1 - Y0

Step3 - Based on the calculated difference in *step-2*, you need to identify the number of steps to put pixel. If dx > dy, then you need more steps in x coordinate; otherwise in y coordinate.

if (absolute(dx) > absolute(dy))

Steps = absolute(dx);

else

Steps = absolute(dy);

Digital Differential Analyzer (DDA) Algorithm

Step 4 – Calculate the increment in x coordinate and y coordinate.

```
Xincrement = dx / (float) steps;
Yincrement = dy / (float) steps;
```

Step 5 – Put the pixel on by successfully incrementing x and y coordinates accordingly and complete the drawing of the line.

```
for(int i=0; i < Steps; i++){
        x = x + Xincrement;
        y = y + Yincrement;
        putpixel(Round(x), Round(y));
}
```

Advantages of (DDA) Algorithm

1. It is simple and easy to implement algorithm.
2. It avoid using multiple operations which have high time complexities.
3. It is faster than the direct use of the line equation because it does not use any floating point multiplication and it calculates points on the line.

Advantages of (DDA) Algorithm

1. It deals with the rounding off operation and floating point arithmetic so it has high time complexity.
2. As it is orientation dependent, so it has poor endpoint accuracy.
3. Due to the limited precision in the floating point representation it produces cumulative error.

Bresenham's Line Drawing Algorithm