Chapter 1. Introduction and Application [2 hrs.]

History of computer graphics, Application of computer graphics, Hardware: Raster - Scan Displays, Vector Displays, Hard copy devices, Input Hardware, Display Architectures, Applications in various fields like medicine, engineering, art, uses in virtual realism.

Introduction:

Computer graphics is the field related to generation(creation), storage and manipulation of graphics(images or pictures) of objects using computer. Objects come from diverse fields, such as physical, mathematical, engineering, architectural, abstract structures, natural phenomenon etc. We see every day the images created by using computer in books, magazines, movies, TV. etc.

The term computer graphics also refers to the tools that are used to make such pictures .These tools includes both hardware and software.

Hardware comprise monitor, printer, plotter (that display graphics) and input devices like mouse, light pen, keyboard, scanner etc.

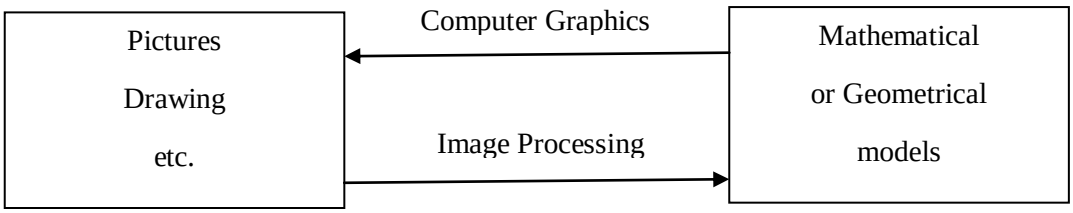
Software tools refers to the collection of graphics routine.

Computer graphics, =Data structure +Graphics algorithm +language

Data structure means those data structure that are suitable for computer graphics. Graphics algorithm for picture generation and transformation. Language means high level language for generation of graphics of objects or pictures.

Difference between Computer graphics and Image processing

Computer graphics	Image Processing
1. It is the field related to the generation of pictures using computers	1. It applies technique to modify or interpret existing pictures.
2. It synthesizes pictures from mathematical or geometrical models	2. It analyze picture to derive description in mathematical or geometrical forms.
3. It is includes the creation, storage and manipulation of images of objects	3. It is the part of computer graphics that handles image manipulation or interpretation
4. Eg. Drawing a picture	4. Eg. Making blurred image visible.



Raster graphics and Vector Graphics:

When a raster image is scaled up . It usually loses quality a raster image can be enlarged by either adding more pixels or enlarging the size of the pixel. Either way you are spreading the original data over a larger area at the risk to losing clarity.

A vector program will use a mathematical formula to build an image that can be scaled to any size without losing quality.

Raster image's dimension are measured in pixels, (remedy pixel quality depends) on pixel dimension, pixel resolution (ppi)

-vector graphics are resolution independence.

Raster graphics: (images mode of pixels, the smallest single, element or point in display device)

- A raster graphics image, digital image, or bitmap is a data file of structure representing a generally rectangular grid of pixels, or points of color on a computer monitor, paper or other display device.
- The color of each pixel is individually defined, images in the RGB color space. For instance, often consist of colored pixel defined by three bytes one byte each for red, green and blue.
- Less colorful images requires less information per pixel, for example an image with only black and white pixels requires only a single bit for each pixel.
- Raster graphics are distinguished from vector graphics in that vector graphics in that vector graphics represent an image through the use of geometric objects such as curves and polygons.

Vector Graphics

-vector graphics (also called geometric modeling or object oriented graphics) is the use of geometrical primitives such as points, lines, curves, and polygons, which are all based upon mathematical equations to represent images in computer graphics.

- it is used by contrast to the term raster graphics, which is the representation of images as a collection of pixel (dots)

- all modern current computer video displays translate vector representation of an image to a raster format. The raster image, containing a value for every pixel on the screen, ins st0red in memory.

History of computer graphics

In 1950's output are via tele types, line printer and cathode Ray Tube (CRT), using dark and light character, a picture can be reproduced 1950.

Been laposky created the first graphic images, a oscilloscope, generated by an electronic (analog) much the image was produced by manipulating electronic the image was produced by manipulating electronic beams and recording them onto high speed film.

1951:UNIVAC-I the first general purpose commercial computer, crude hardcopy devices, and line printer pictures.

1951: MIT-whirlwind computer, the first to display real time video and capable of displaying real time text and graphic on a large oscilloscope screen.

In 1960's beginnings of modern interactive graphics,output are vector graphics and interactive graphics, one of the worst problems was the cost and in accessibility of machine.

In midsole 1950's SAGE (Semi automatic ground Environment) air defenses system was developed It was the first to use command and control CRT display consoles on which operator identifies target, with light pen (hand –held pointing devices that senses light emitted by objects on screen)

1960: William Felter coins the computer graphics to describe new design methods.

1961: Stove Russel –space wars, first video/computer game

1963: Douglas Englebart-first mouse.

1963: Ivan Sutherland –sketch pad , interactive C.G. System, a man machine graphical communication system, it features:

Pop-up menus.

Constrained –based drawing

Hierarchal modeling

Utilized light pen for interaction

He developed the dragging, rubber banding and transforming algorithms, He introduced data structures for storing. He is considered data founded of computer graphics.

1964: William Felter –first computer model of a human figure.

1965: Jack Bresenham-line drawing algorithm.

1968: Tekronix –a special CRT, the direct view storage tube, with keyboard and mouse, a simple computer interface for $15,000 which made graphics affordable.

1969:

John Warnock-area subdivision algorithm, hidden –surface algorithms

Bell labs –first frame buffer containing 3 bits per pixel

-CAD (Computer Aided design)

-CAM (Computer Aided Manufacturing)

Had enormous potentials for autometing draftnly and other drawing –intensive activities.

-The general motto DAC system for hens design were poineriy efforts that showed the utility of graphical interaction in the interactive design cycles common in engineering.

-A no. of commercial products using these system had appeared. But high cost of hardware.

In the early 1970's. Output start using raster displays, graphics capability was still fairly chunky 1972-Nolan kaybushvell Pong, video acade game.

1973: John whitiney Jr. and Gary Demos-Westworld", first film with computer graphics.

1974: Edwin catmuff –texture mapping and z-buffer hidden surface algorithm

James Blim –curved surfaces, refinement of texture mapping

1971: Gourand shading (rendering mode)

1974-77: phong shading (rendering mode)

1977: slave wozmak…Apple II, color graphics personal computer

In the 1980's output are built in raster graphic, bitmap image and pixel, personal computer cost decrease drastically, trackball and mouse become the standard interactive devices.

1980's Artists and graphic designers preferred to use macintosh and pc's late 1980's artists and graphic designers preferred to use macintosh and pc's

1982: Ray tracing (Illumination based rendering method)

1982: steven lisberge-Tron', first Disney movie which makes extensive use of 3-D computer graphics John Walkner and Dan Drake-Auto CAD

1983: Jaron lanier 'Data Glove" a virtual reality film features a glove installed with switches and sensors of generated hand motion

1984: Wavefrom tech: polhemus, first 3D graphics software

1987: IBM-VGA, video graphics Array introduced

1989: Video electronics standard association (VESA)-SVGA super VGA formed

In 1990's since the introduction of VGA and SVGA personal computer could easily display photo realistic images and movies 3D image rendering are become the main advances and it stimulated cinematic graphics application.

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In 1990- Render man system that provides fast accumulate and high quality digital computer effects.

1992- Silicon graphic –open GL specification

1993- mosaic, first graphic web browser. Jurrasic park a successful cg fiction film.

1995: 'Toy story' first full length computer generated feature film.

2003: ID software –Doom graphics engine.

Uses of computer graphics:

1. User interfaces
2. Plotting
3. Office automation and electronic publishing
4. Computer aided drafting and design
5. Scientific and business visualization
6. Simulation
7. Entertainment
8. Art and commerce
9. Cartography
10. Medical imaging

1. **User interfaces**

   - Most application have user interfaces that rely on the desktop window systems to manage multiple simultaneous activities and on point and click facilities to select items menu, icon, objects on the screen.

-Typing is necessary, spread sheet and desktop publishing programs are the typical examples where user interface technique are implements

2. **plotting**

-plotting 2D and 3D graphs of mathematical, physical and economic functions uses computer graphics extensively.

-The histograms, bar and pie charts the task scheduling charts are the most commonly used plotting.

-These are allused to present meaningfully and concisely the trend and pattern of complex data.

3. Office automation and electronic publishing

-computer graphics has facilitated the office automation and electronic publishing which is also popularly known as desktop publishing, giving more power to the organization to print the meaningful material in house.

-office automation and electronic (softcopy) document that contain text, tables, graphs and other form of drawn and scanned in graphics.

4. Computer aided drafting and design.

- One of the major uses of computer graphic is to design components and systems of mechanic electrical, electrochemical and electronic devices including structures such as building, auto mobile bodies, and airplane and ship hull, very large scale integrated (CLSI) chips, optical systems and telephone and computer networks

- These designs are more frequently used to test structural electrical and thermal proper of the systems.

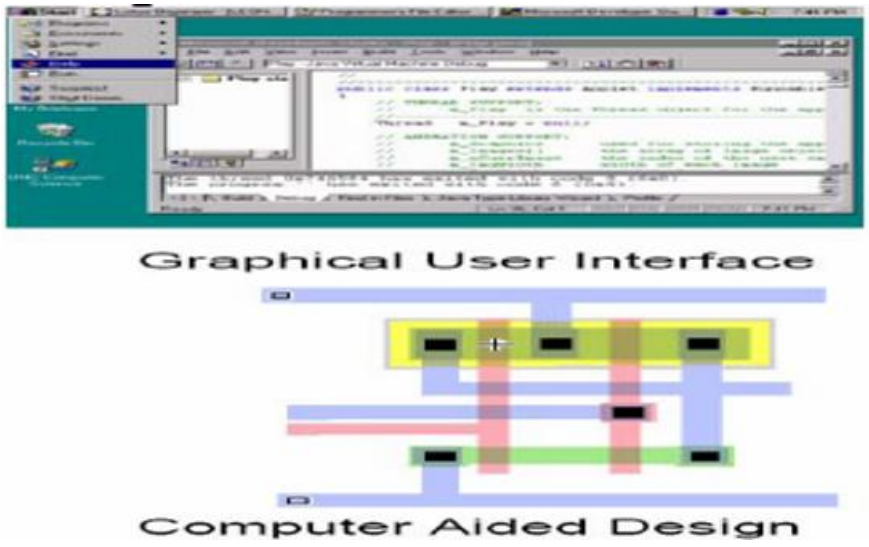


Fig 1.1: GUI and computer aided design

5. Scientific and business visualization

-Generating computer graphics for scientific engineering and medical data sets is term as scientific visualization whereas business visualization is related with the non scientific data sets such as those obtained in economic.

- Visualization makes easier to understand the trends and pattern inherent in huge amount of data sets. It would otherwise be almost impossible to analyze those data numerically

6. Simulation.

- Simulation is the imitation of the conditions like those, which is encountered in real life. - Simulation thus helps to learn or feel thecondition one might have to face in near future without being in danger at the beginning of the course.

-For example, astronauts can exercise the feeling of weightlessness in a simulator, similarly a pilot training can be conducted in a flight simulator.

-The military tank simulator, the naval simulator, driving simulator, air traffic control simulator, heavy duty vehicle simulator and so on are some of the mostly used simulator in practice. -Simulators are used to optimize the system.

-E.g. The vehicle observing the reactions of the driver during the operation of the simulator

7. Entertainment:

-Disney movies such as lion king and the beauty and the beast, and other scientific movies like star trek are the best examples of application of computer graphics in the field of entertainment.

-Instead of drawing all the necessary frames with slightly changing scenes for the production of cartoon film only the key frames are sufficient for such cartoon film where the in between frames are interpolated by the graphics system dramatically decreasing the cost production while maintaining the quality.

-computer and video games such as FIFA, formula-1, Doom and pools are few to name where computer graphics is used extensively

8. Art and commerce.

-computer graphics is used to produce picture that express a message and attract attentions such as a new model of a car moving along the ring of the Saturn.

- These pictures are frequently seen at transportation terminal, super markets, hotel etc, the slide production for commercial, scientific or education presentation is another cost effective use of computer graphics one of such graphics package is power point.

9. Cartography:

-cartography is a subject which deals with the marketing of the maps and chart. Computer graphic is used to produce both accurate and schematically representation of geographical and other natural phenomenon from measurement data. It includes geographic map, oceanographic chart, weather map, color map and population density map. Surfer is one of such graphic package which in extensively used for cartography.

10. Medical imaging.

- X-ray, video X-ray, complex operation etc. are the uses of computer graphics in medical field.

General term and terminologies:

1. **Fluorescence /phosphorescence :**

- When the electron beam strikes the phosphor- coated screen of the CRT the individual electron are moving with the kineticenergy proportional to the acceleration voltage.
- Some of this energy is dissipated as heat but the rest is transferred to the electron of the phosphor atoms making them jump to higher quantum energy level.
- The difference between the energy level determine the color of light that emits (Quantum theory)
- Fluorescence is the light emitted as these very unstable electrons lose their excess energy while the phosphor is being struck by electrons
- Fluorescence is the light emitted by very unstable electron to come into higher quantum energy level.
- Phosphorescence is the light given off by stable excited electron to their unexcited state once the electron beam excitation is removed.
- Fluorescence usually last for a fraction of micro second.
- Most of the light emitted is phosphorescence

2. **Persistence**

- How long phosphors continue to emit light (that is to have excited electron returning to ground state) after the CRT beam is removed
- Time is text the emitted light from the screen to decay to $1/10^{th}$ of its original intensity.
- That is how long phosphorescence persist.
- Lower persistence phosphors require higher refresh rates to maintain a picture on the screen without flicker.
- The phosphor with low persistence is useful for animation and a high persistence phosphor is useful to highly complex static pictures.
- Graphics monitors are usually constructed with persistence in the range from 10 to 60 micro second.

3. **Refresh Rate**

- Because the light emitted by the phosphor fade very rapidly, some method is needed maintaining the screen picture.
- One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly direction the electron beam back over the same points.
- Refresh rate is the number of times, the image is redrawn to give a feeling of unflick picture per second.
- Usually 50/sec.

- Refresh rate above which flickering stops is called Critical Fusion Frequency (CFF). The factor affective CFF are persistence, image intensity, Ambient room light , wave length of emitted light, observer.

4. Horizontal scan rate

- The horizontal scan rate is the number of scan lines per second. The rate is approximately the product of the refresh rate and the number of scan lines.

5. Resolution

- Maximum number of points that can be displayed without overlaps horizontally and vertically without overlap on a display device more precisely, it is the number of pixels per unit length that can be placed horizontally and vertically.

Factors affecting the resolutions are as follows:

i. **Spot profile:** The spot intensity has a Gaussian distribution as depicted in figure. So two adjacent spots on the display device appear distinct as long as their separation D2 is greater than the diameter of the spot D1 at which each spot has an intensity of about 60 percent of that at the center of the spot.

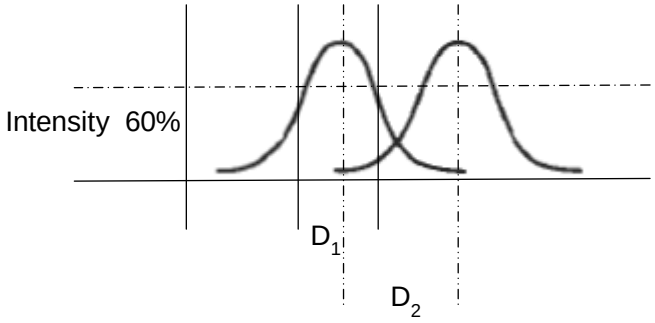


Fig 1.2: Gaussian distribution of spot intensity

ii. **Intensity:** As the intensity of electron beam increases the spot size on the display tends to increase because of spreading of energy beyond the point of bombardment.

This phenomenon is called blooming, consequently the resolution decreases.

6. Aspect Ratio:

- The ratio of vertical points to horizontal points necessary to produce equal length lines in both direction on the screen. Aspect Ratio 3/4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.

7. Horizontal and vertical retrace:

- At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line. The return to the left of the screen, after refresh each scan line is called the horizontal refresh of the electron beam.

- At the end of each frame, ($1/50^{th}$ of a second) the electron beam returns to the top left corner of the screen to begin the next frame.

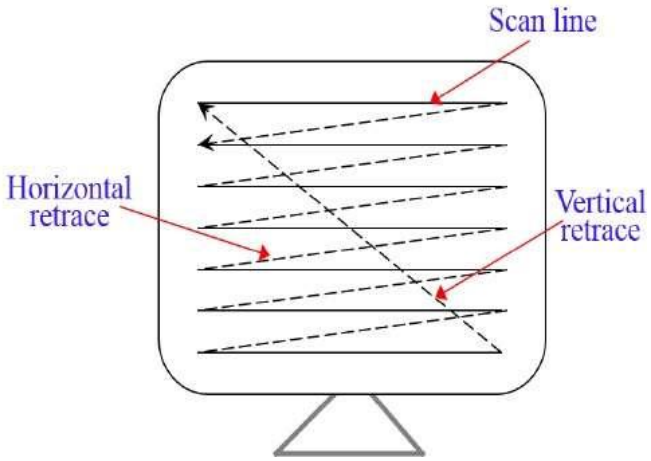


Fig 1.3: Scan line, horizontal retrace and vertical retrace

8. Refresh Buffer/ frame buffer/ bit map/ pix map:

- In raster- scan system, the electron beam is swept across the screen, one row at a time from top to bottom. As the electron beam moves across each the beam intensity turned on and off to create a pattern of illuminated spots.
- Picture definition is stored in a memory are called the refresh buffer or frame buffer.
- This memory area holds the set of intensity values for all the screen points. Stored intensity values arethen retrieved from the refresh buffer and 'painted' on the screen one row (scan line) at a time. Each screen point is referred to as a pixel or pel (picture element).
- On black and white system with one bit per pixel, the frame buffer is commonly called a bit map. For system with multiple bits per pixel, the frame buffer is commonly called a bit map.

Color depth	Number of color displayed	Byte of storage per pixel	Common Name for color depth
4-bit	16	0.5	Standard
8-bit	256	1	256 color mode
16 bit	65, 536	2	High color
24 bit	16,717,216	3	True color

1. If pixels are accessed from the frame buffer with an average access the 300ns. Then will this rate produce the flickering effects? (screen resolution=640x480)

Here,

Access time for 1 pixel =300ns.

Access time for 640 X 480 pixels= 640 x 480 x 300ns

So, frequency = 1/t

$=1*10^9/640*480*300$

= 10.85 fps(< 50fbs, so flicker occurs)

2. If the total intensity available for a pixel is 256 and the screen resolution is 640 x 480. What will be the size of the frame buffer.

Size in frame buffer for 1 pixel = 8 bit

For 640 x 480 = 640 x 480 x 8 bits

= 300k bytes.

3. Consider 256 pixel x 256 scan lines image with 24 bit true color. If 10 minutes video is required to capture, calculate the total memory required ?

For 1 sec = 256 x 256 x 3 x 50 Bytes

For 10 minute=(256*256*3*50*10*60)/(1024*1024*1024)

= 5.49 GB

Hardware concepts:

1. **Tablet**

- Tablet is a digitizer, a device which is use to scan over an object and input a set of discrete co-ordinate positions.
- These positions can be then joined with straight line segments to approximate the shape of original object.
- A tablet digitizes an object detecting the position of a movable stylus (a pencil shaped device) or a puck (a mouse like device with cross hairs for sighting positions) held in the user's hand.
- A tablet is a flat surface and its size varies from 6 by 6 inches upto 48 by 72 inches or more.
- The accuracy of the tablet usually falls below 0.2 mm.

Three types of tablet

i. Electrical tablet
ii. Sonic tablet
iii. Resistive tablet

i. Electrical tablet

- A grid of wives on ¼ to ½ inch centers is embedded in the tablet surface.
- Electromagnetic signals generated by electrical pulses applied in sequence to the wires in the grid induce an electrical signal in a wire coil in the stylus or puck.
- The strength of the signal induced by each pulse is used to determine the position of the stylus.
- The signal strength is also used to determine roughly how far the stylus is from the tablet
- When the stylus is within ½ inch from the tablet it taken as near otherwise it is either "far" or "touching"
- When the stylus is near or touching, a cursor is usually shown on the display to provide visual feedback to the user
- A signal is sent to the computer when the tip of the stylus is pressed against the tablet or when any button on the puck is pressed
- The information provided by the tablet repeats 30 to 60 times per second
-

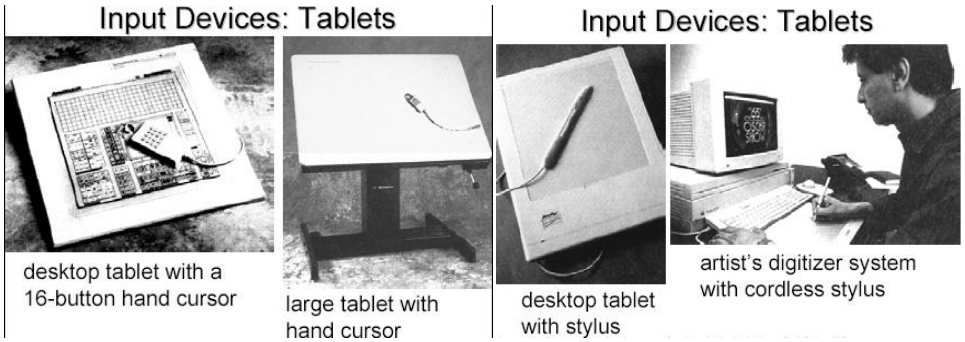


Fig 1.4:Tablets

ii. Sonic tablet

- The sonic tablet uses sound waves to couple the stylus to microphones positioned on the periphery of the digitizing area.
- An electrical spark at the tip of the stylus creates sound bursts. The position of the stylus or the co- ordinate values is calculated using the delay between when the spark occurs and when its sound arrives at each microphone.
- The main advantage of sonic tablet is that it doesn't require a dedicated working area as the microphones can be places on any surface to form the tablet work area.
- This facilitates digitizing drawing on thick books because in an electrical tablet this is not convenient for the stylus can not get closer to the tablet surface

iii. Resistive tablet

- The tablet is just a piece of glass coated with a thin layer of conducting material.

- When a battery is powered stylus is activated at certain it emits high frequency radio signals which induces the radio signals on conducting layer.
- The strength of the signal received at the edges of the tablet is used to calculate the position of the stylus.
- Several types of tablets are transparent, and thus can be backlit for digitizing x-ray films and photographic negatives.
- The Resistive tablet can be used to digitize the objects on CRT because it can be curved to the shape of the CRT.
- The mechanism used in the electrical or sonic tablets can also be used to digitize the 3D objects

2. Touch Panels

- The touch panel allows the user to point at the screen directly with a finger to move the cursor around the screen or to select the icons. There are three types of touch panels.
- i) Optical Touch Panel
- ii) Sonic Touch Panel
- iii) Electric Touch Panel

i) Optical Touch Panel :

- It uses a series of intra red light emitting diodes (LED) along one vertical edge and along one horizontal edge of the panel.
- The opposite vertical and horizontal edge contact photo detectors to from a grid of invisible infrared light beams over the display area.
- Touching the screen breaks one or two vertical and horizontal light beams there by indicating the fingers position.

ii) Sonic Touch Panel :

- Bursts of high frequency sound waves traveling alternately horizontally and vertically are generated at the edge of the panel.
- Touching the screen causes part of each wave to be reflected back to its source.
- The screen position at the point of contact is then calculated using the time elapsed between when the wave is emitted and when it arrives back at the source.

iii) Electrical Touch Panel

- It consists of slightly separated two transparent panel one coated with a thin layer of conducting material and the other with resistive material.
- When the panel is touched with a finger the two plants are forced to touch at the point of contact there by creating the voltage drop across the resistive plate which is then used to calculate the co-ordinate of the touched position.

3. Light Pen :

- It is a pencil shaped device to determine the co-ordinates of a point on the screen where it is activated such as pressing the button.
- In raster display 'y' is set at Ymax and 'X' changes from o to Xmax the first scan line.
- For the second line 'Y' decreases by one and 'X' again changes from o to Xmax and so on.

- When activated light pen sees a burst of light at certain position as the electron beam hits the phosphor coating at that position it generates an electric pulse.
- This is used to save the video controller's 'X' and 'Y' registers and interrupt the computer.
- By reading the saved valued the graphics package can determine the co-ordinates of the position seen by the light pen.

4. Keyboard :

- Creates a code such as ASCII uniquely corresponding to a pressed key.
- Consists of alphanumeric key, function keys, courser-control keys and separate numeric pad.
- Used to move the cursor, to select the menu, item, predefined functions. In computer graphics keyboard is mainly used for entering screen co-ordinate and text to invoke certain functions. Now-a-days ergonomically designed keyboard (Ergonomic keyboard) with removable palm rests is available. The slope of each half of the keyboard can be adjusted separately.

5. Mouse :

- A small hand held device used to position the cursor on the screen.
- Mice are relative device that is they can be picked up, moved in space and then put down again without any change in the reported position.
- For this, the computer maintains the current mouse position, which is incremented or decremented by the mouse movements. Following are the mice, which are mostly used in computer graphics.

i) Mechanical mouse :

- When roller in the box of this mechanical mouse is moved a pair of orthogonally arranged toothed wheels, each place in between LED and a photo detector, interrupts the light path. The number if interrupts so generated are used to report the mouse movements to the computer.

ii) Optical mouse :

- The optical mouse is used on a special pad having grid of a alternating light and dark lines.
- A LED in the bottom of the mouse directs a beam of light down onto the pad from which it is reflected and sensed by the detectors on the bottom of the mouse. As the mouse is moved the reflected light beam is broken each time a dark line crossed. The number of pulses so generated, which is equal to the number of lines crossed are used to report mouse movements to the computer.

6. Barcode reader :

- A barcode reader (or barcode scanner) is an electronic device for reading printed barcodes.
- Like a flatbed scanner, it consists of a light source, a lens and a light sensor translating optical impulses into electrical ones.

- Additionally, nearly all barcode readers contain decoder circuitry analyzing the barcode's image data provided by the sensor and sending the barcode's content to the scanner's output port.

7. Data Glove :

- A data glove is an interactive device resembling a glove worn on the hand, which facilitates tactile sensing and fine-motion control in robotics and virtual reality.
- Data gloves are one of several types of electromechanical devices used in haptic applications.
- Tactile sensing involves simulation of the sense of human touch and includes the ability to perceive pressure, linear force, temperature and surface texture.
- Fine-motion control involves the use of sensors to detect the movements of the user's hand and fingers and the translation of these motions into signals that can be used by a virtual hand (for example in gaming) or a robotic hand (for example in remote-control surgery).

Refresh Cathode Ray Tube :

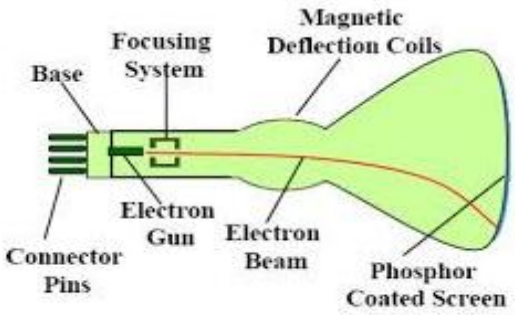


Fig 1.5: Basic design of a magnetic-deflection CRT

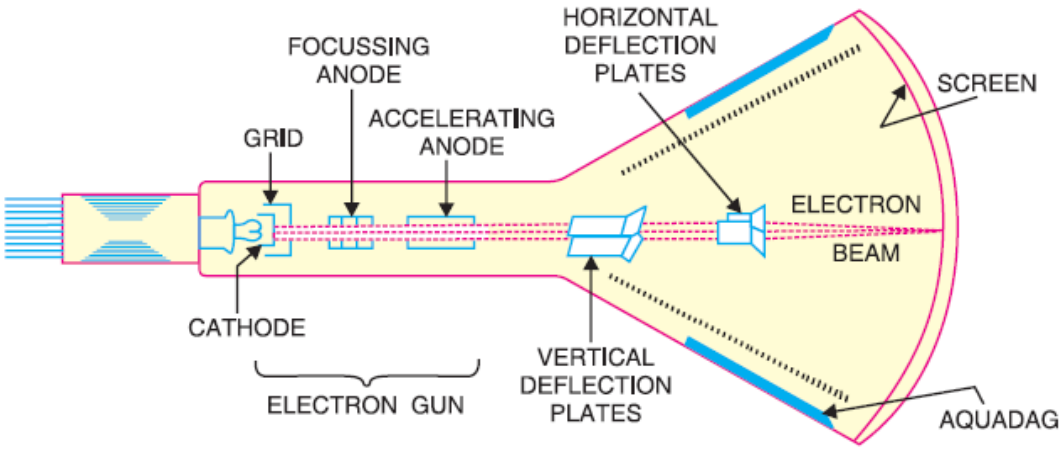


Fig 1.6 : Operation of an electron gun with an accelerating anode.

- Consists of a CRT along with control circuits.
- CRT is a vacuum glass tube with the display screen at one end and connectors to the control circuits at the other.
- Inside of display screen is a special material called phosphor which emits light for a period of time when hit by a beam of electrons.\
- The color of light and the time period vary from one type of phosphor to another.

Refresh CRT Parts :

1) Electron Gun :
- Made up of heated metal cathode and a control grid.

1.1) Heated metal cathode :
- Heat is supplied to the cathode by directing a current through acoil by wire, called heating filament, inside the cylindrical cathode structure.
- This cause electron to be "boiled off: the cathode surface.

1.2) Control Grid :
- Responsible to control the brightness of a display.
- By setting voltage level on control grid, the brightness emitted by phosphor coating depends of the no. of electrons that strike the phosphor coat.

2) Accelerating Anode :
- In the vacuum inside the CRT envelops, the freely negatively charged electrons, are then accelerated towards electrons, are then accelerated towards the phosphor coating by a high positive voltage (15000-20000).
- This high positive voltage can be generated by using accelerating anode.

3) Focusing system/Focusing Anode :
- Required to force the electron beam to converge into small spot when it strikes the phosphor coat.
- Otherwise the electrons would repel each other and the beam would spread out as it approaches the screen.
- Electrostatic Focusing
- Magnetic Field Focusing
- Additional focusing hardware is used in high precision systems to keep the beam in focus at all screen positions.
- Because of radius of curvature for CRT monitor as beam moves to the outer edges of the screen displayed image may be blurred. To adjust this the focusing is necessary.

4) Deflection System :
- Needed to direct the electron beam towards a particular point on the screen done in two ways.

- Electrostatic deflection system
- Magnetic deflection system
- When electron beam passes through the horizontal and vertical deflection plated, it is bent or deflected by the electric fields between the plates.
- The horizontal plates control the beam to scan from left to right and retrace from right to left (horizontal retrace).
- The vertical plates control the beam to go from the first scan line at the top to the last scan line at the bottom and retrace from the bottom back to the top (known as vertical retrace).

Raster Scan Displays :

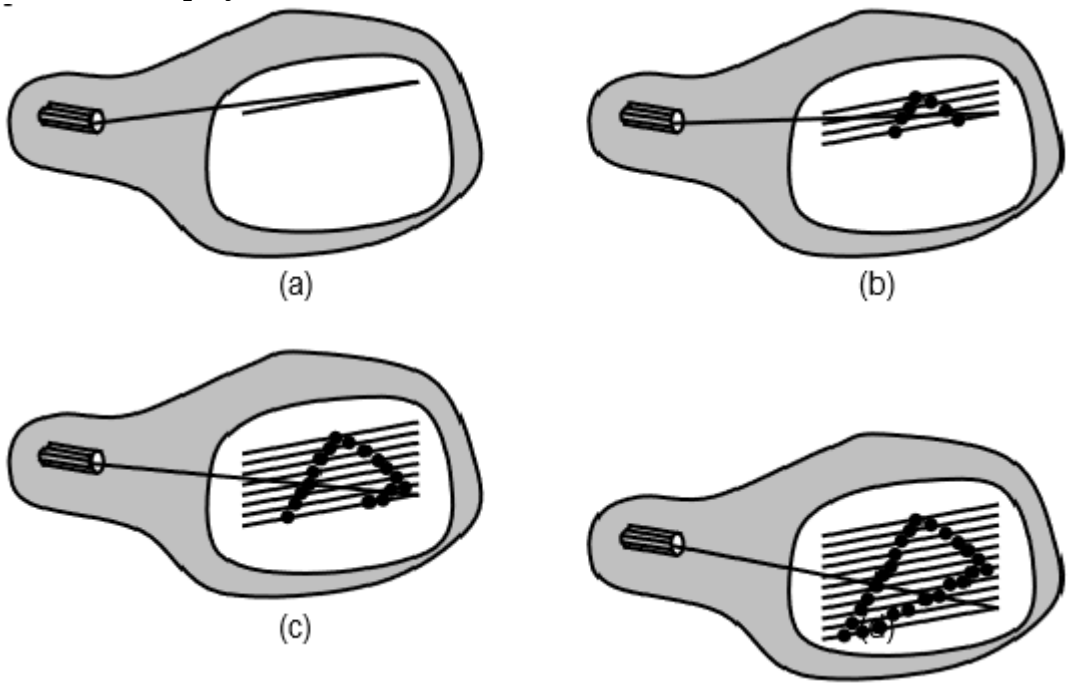


Fig 1.7: Raster Scan Display

- Most common type of graphics monitor employing a CRT (based on Television Technology).
- The electron beam is swept across the screen one row at a time from top to bottom.
- Picture definition is stored in memory area called :refresh buffer" or "frame buffer".
- The set of intensity values is retrieved from refresh buffer and "painted" on the screen one row at a time.
- Each screen point is referred as a "Pixel" or "Pell".
- For black and white system each screen point is represented by one bit is per pixel "On" or "Off".
- For color system, additional bit is needed to represent single pixel. (24 bit per pixel in high quality systems).
- For black and white system, one bit per pixel, this frame buffer is called "Bitmap" whereas for system with multiple bits per pixel, the frame buffer is called "pixmap".

- Refresh rate is 50-60 frame per second
- Horizontal Retrace
- Vertical Retrace

Interlacing :

Some monitors use a technique called "interlacing" to double the refresh rate. In this case, only half of the scan lines in a frame is refreshed at a time, first the odd numbered lines, and then the even numbered lines. Thus, the screen is refreshed from top to bottom I half the it would have taken to sweep across all the scan line. This effect is quite effective in reducing flicker.

Random (Vector) Scan Display :

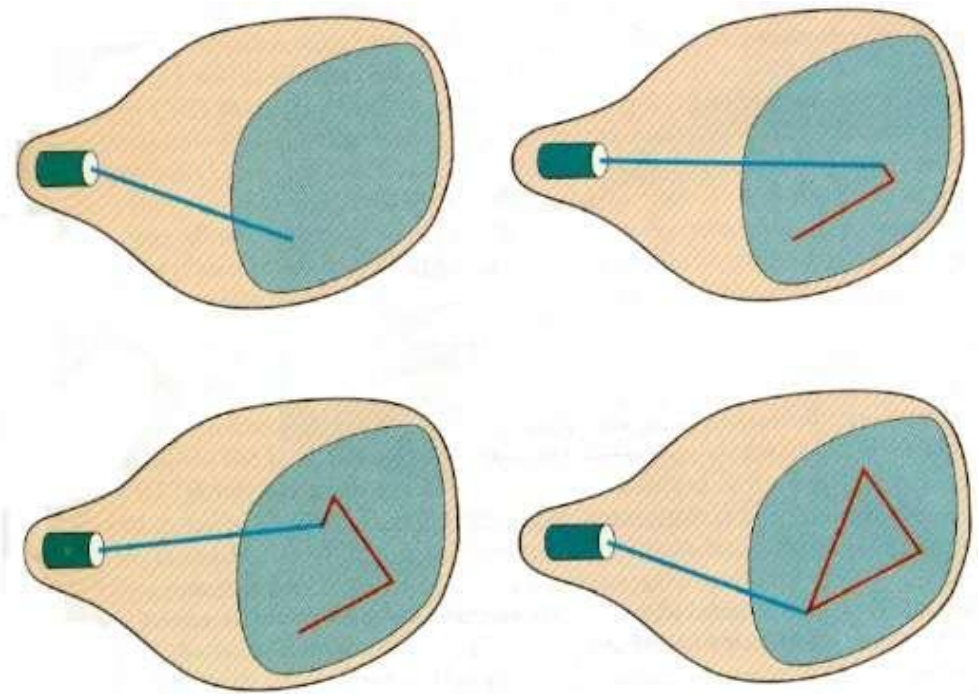


Fig 1.8: Vector Scan Display

- Electron beam is directed only to the points of the screen where a picture is to be drawn eg. Pen plotter (hard copy device).
- Also called vector displays
- Refresh rate depends on the number of lines to be displayed.
- Picture definition is stored as a set of line drawing commands in system memory called display file (or display program or display list).
- To display a specified picture the system cycles through the set of commands in display file, drawing each component line in turn. After all line drawing commands have been processed, the system cycles back to the first line command in the list.

- Random scan displays are designed to draw all the components of a picture 30 to 60 times each second.

Difference between Raster Scan Display and Random (Vector) Scan Display

Base of Different	**Raster scan display**	**Random (vector) scan display**
1) Electron Beam	The electron beam is swept across the screen one row at a time from top to bottom.	The electron beam is swept to the parts of the screen where a picture is to be drawn.
2) Resolution	It has lower or poor resolution because picture definition is stored as an intensity value.	It has high resolution because it stores picture definition as a set of line commands.
3)Picture definition	Picture definition is stored as a set of intensity values for all screen points (pixels) in a refresh buffer.	Picture definition is stored as a set of line in a display list or file.
4)Realistic display	The capacity of the system to store intensity values for pixels make it well suited for realistic display with shadow and color pattern.	These system are designed for line-drawing and can't display realistic shaded scenes.
5)Image drawing	Screen points or pixels are used to draw an image.	Mathematical functions are used to draw an image.
6)Cost	They are cheaper than random display.	It is more expensive than raster-scan display.
7)Refresh rate	Refresh rate is 60-80 fps.	All components are drawn 30 to 60 times per second.
8)Interlacing	It uses interlacing.	It doesn't use interlacing.
9)Editing	Editing is difficult.	Editing is easy.
10)Refresh area	Refresh area is independent of picture complexity.	Refresh area depends on complexity of picture.
11)Smoothness	Produce jagged line.	Produce smooth line.
12)Example:	CRT, TV, Printer	Pen Plotter

Color CRT Monitors :

- Displays color pictures using a combination of phosphors that emits different colored light.

Two basic techniques are available

i. Beam Penetration Method
ii. Shadow Mask Method

i. Beam Penetration Method

- Two different layers of phosphor coating used Red (outer) and Green (inner).
- Display of color depends on the depth of penetration of electron beam into the phosphor layer.

i. A beam of slow electron excites only the outer red layer.
ii. A beam of very fast electrons penetrates through the red phosphor and excites the inner green layer.
iii. When quantity of red is more than green then color appears as orange.
iv. When quantity of green is more than red then color appears as yellow.

Screen colors as controlled by the beam acceleration voltage. Only four colors possible, poor picture quality.

ii. Shadow Mask Method:

- The inner side of the viewing surface of a color CRT consists of closely spaced groups of red, green and blue phosphor dots. Each group is called a triad.
- A thin metal plate perforated with many small hole is mounted close to the inner side of the viewing surface. This plate is called shadow mask.
- The shadow mask is mounted in such a way that each hole is correctly aligned with a triad in color CRT.
- There are three electron guns one for each dot in triad.
- The electron beam from each gun therefore hits only the corresponding dot of a triad as the three electron beams deflect.
- A triad is so small that light emanatory from the individual dots is perceived by the viewer as a mixture of the three colors.

Two types of shadow mask method:

a. Delta- Delta CRT
b. Precision inline CRT

a. Delta- Delta CRT

- A triad has a triangular or delta pattern as are three electron guns.

- Main drawback of this a high precision display is very difficult to achieve because of technical difficulties involves in the alignment to shadow mask holes and the triad on one to one basis.

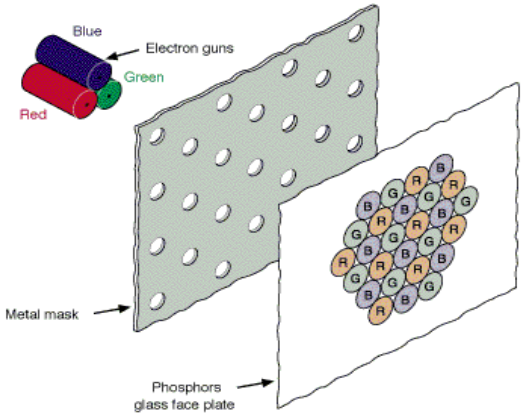


Fig 1.9: Delta - Delta CRT

b. Precision Inline CRT:

- A triad has an *in-line pattern* as are the three electron guns
- The introduction of this type of CRT has eliminated the main drawback of a Delta-Delta CRT
- Normally 1000 scan lines can be achieved.

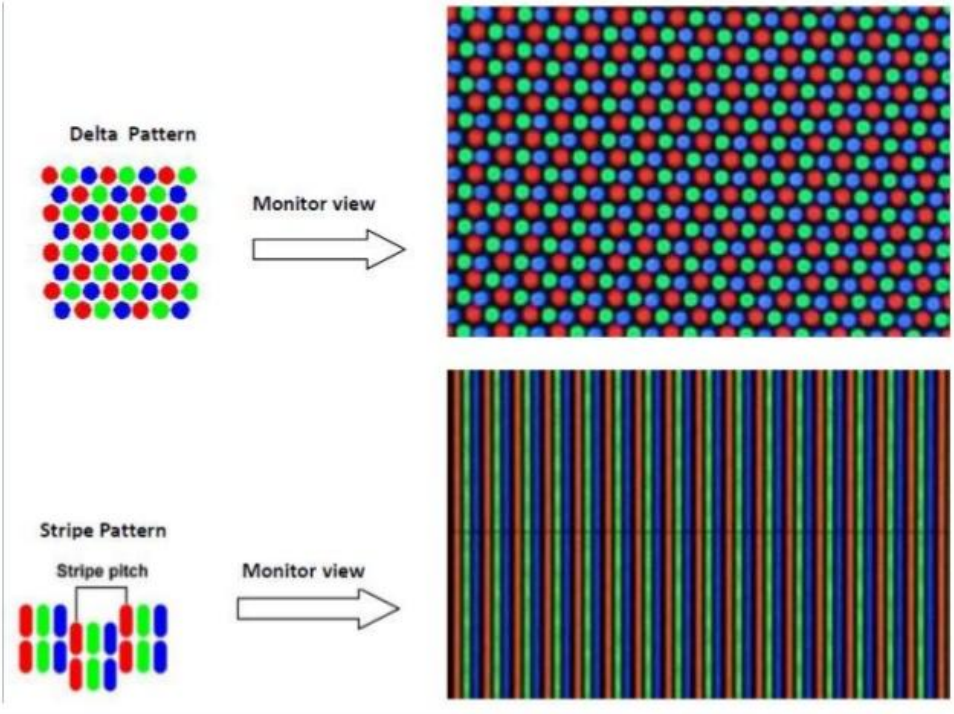


Fig 2.0: Delta-Delta and Precision Inline CRT

- But a slight reduction of image sharpness at the edges of the tube has been noticed
- Normally 1000 scan lines can be achieved
- The necessity of triad has reduced the resolution of a color CRT
- The distance between the center of adjacent triads is called a *pitch*
- In very high resolution tubes, pitch measures 0.21 mm (0.61 mm for home TV tubes)
- The diameter of each electron beam is set at 1.75 times the pitch
- For example if a color CRT is 15.5 inches wide and 11.6 inches high and has a pitch of 0.01 inches
- The beam diameter is therefore 0.01 x 1.75 = 0.018 inches
- Thus the resolution per inch is about 1/0.018 = 55 lines
- Hence the resolution achievable for the given CRT is 15.5 x 55 = 850 by 11.6 x 55 = 638
- The resolution of a CRT can therefore be increased by decreasing the pitch
- But small pitch CRT is difficult to manufacture because it is difficult to set small triads and the shadow mask is more fragile owing to too many holes on it .
- Besides the shadow is more likely to warp from heating by the electrons

Raster scan display system/ architecture/ technology:

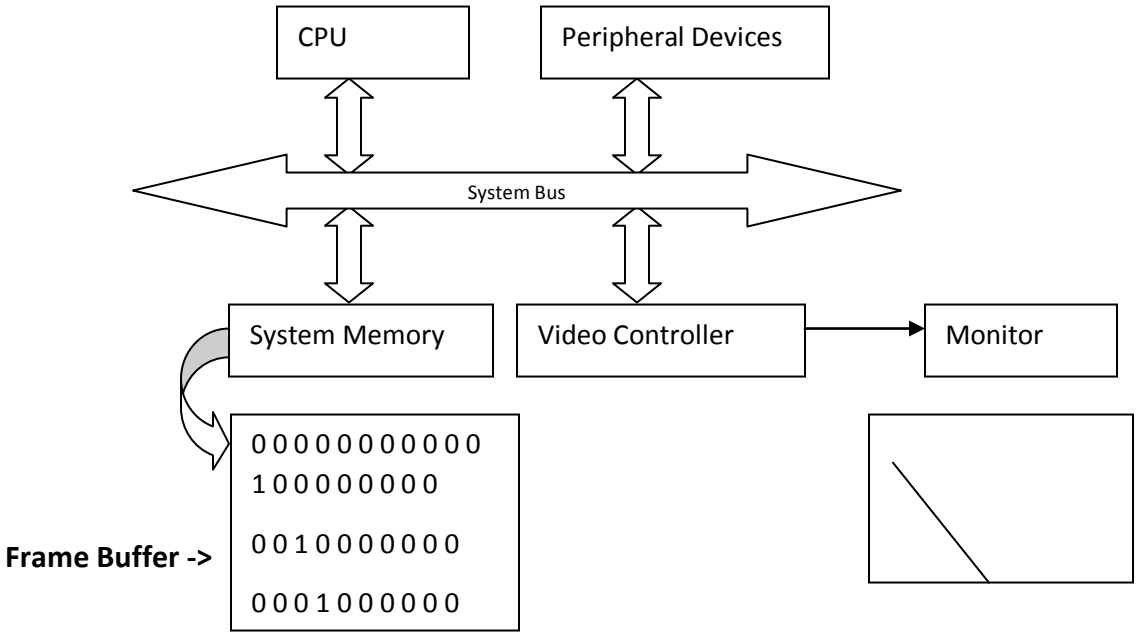


Fig 2.1: Raster Scan System

- Consists of CPU, a video controller (special- purpose processor), a monitor, system memory and peripheral devices.

Advantages

- It has an ability to fill the areas with solid colors or patterns
- The time required for refreshing is independent of the complexity of the image

- Low cost

Disadvantages

- For Real-Time dynamics not only the end points are required to move but all the pixels in between the moved end points have to be scan converted with appropriate algorithms Which might slow down the dynamic process
- Due to scan conversion "*jaggies*" or "*stair-casing*" are unavoidable

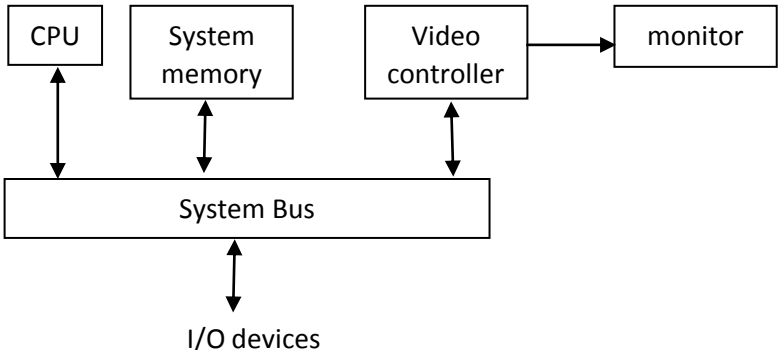


Fig 2.2: Architecture of a simple raster graphics system.

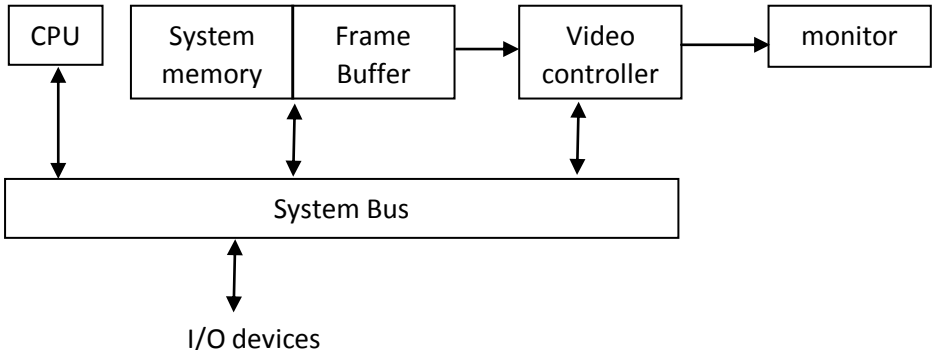


Fig 2.3: Architecture of RS with a fixed portion of the system memory reserved for the FB.

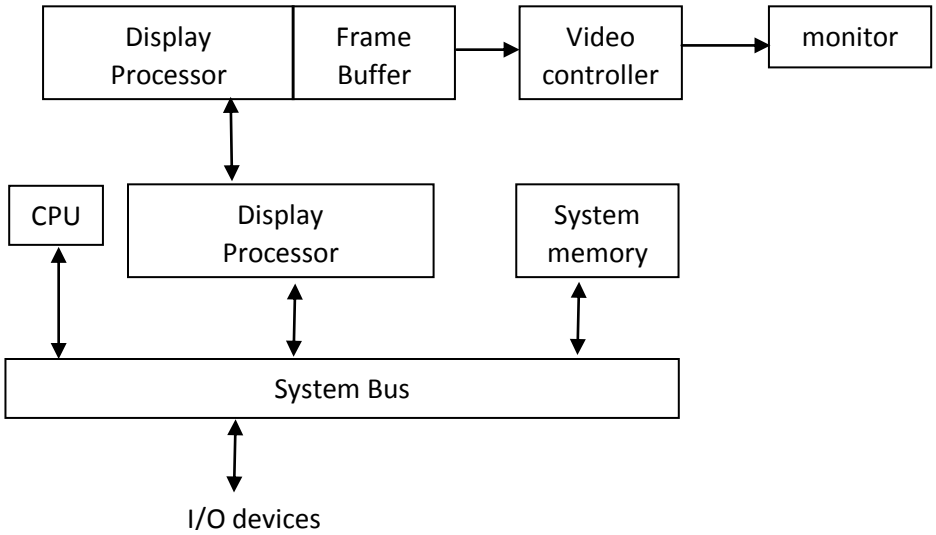


Fig 2.4: Architecture of a raster- graphics system with a display processor.

- Application program and graphics sub routine package both resides in system memory and executes in CPU.
- When particular command (eg. line (x_1, y_1, x_2, y_2)) is called by application program the graphics sub routine package sets the appropriate pixels in the frame buffer. The video controller then cycles through the frame buffer, one scan line at the time (50 fps).
- It brings a value of each pixel contained in the buffer.

Video Controller:

- A fixed area of the system memory is reserved for frame buffer and video controller is given direct access to the frame- buffer memory to refresh the screen.

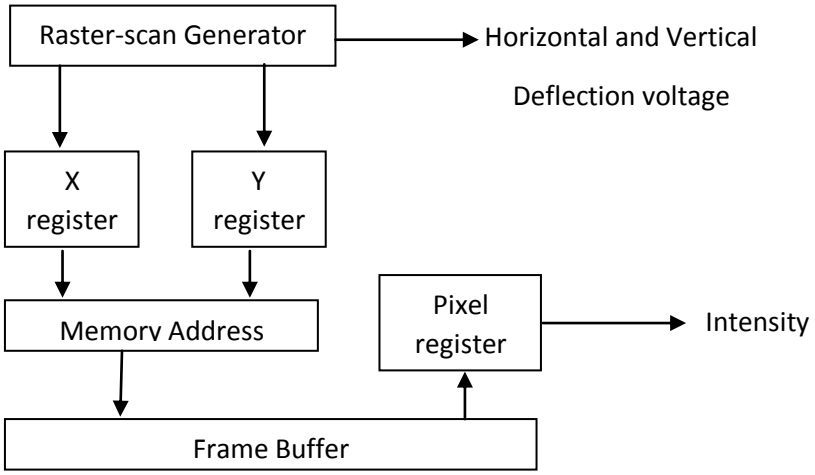
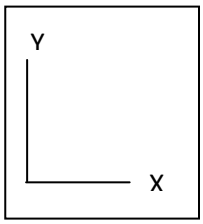


Fig 2.5: Basic video- controller refresh operation.



- The screen positions are referenced in Cartesian co-ordinate. Origin is defined as the lower left screen corner. The screen surface is then represented as the first quadrant of 2D- system. Two registers are used to store c0-ordinates of screen pixel.
- Initially, Y-register is set to Y_{max} and X to 0.
- The value stored in frame buffer for this pixel is retrieved and used to set intensity of CRT beam.
- Then X-register is incremented by 1 and same process is repeated for each pixel along scan line as before.
- After cycling through all pixels along bottom scan-line (y=0), video controller resets register to first position on top scan line and refresh process starts again.
- Since the refreshing per pixel is slow process, the video controller retrieves the intensity values for a group of adjacent pixels from the frame buffer. This block of pixel intensity is stored in separate registers and used to control the CRT beam intensity for a group of adjacent pixels on the screen.

- Video controller can retrieve pixel intensities from different memory areas on different refresh cycles.

Display Processing Unit (DPU):

- Also called graphics controller or display co-processor.
- Purpose of display processor is to free the CPU from graphic chores (manipulation).
- It has its own memory.
- The major task is digitizing a picture definition given in an application program into a set of pixel intensity values for storage in frame buffer.
- The digitization process is called scan conversion.

DPU also performs:

- Generating various line style (dashed, dotted, solid lines).
- Displaying color areas.
- Performing various transformation.

Random– scan system/ architecture/ technology.

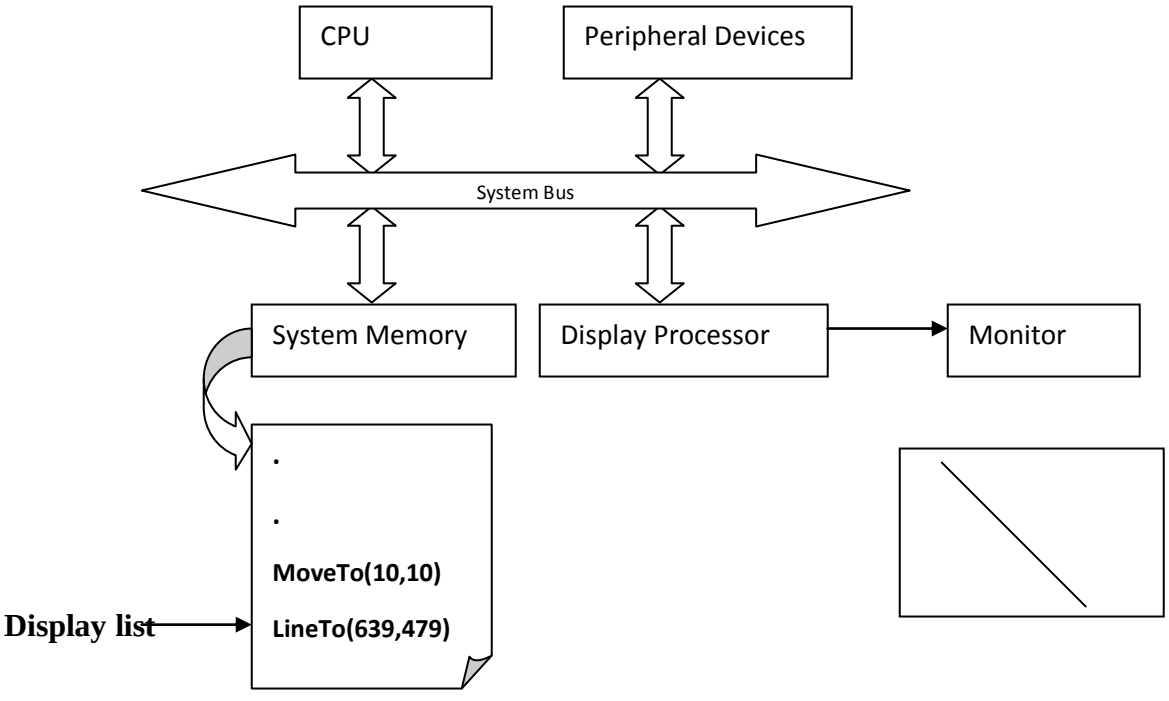


Fig 2.6: Architecture of a simple random– scan system

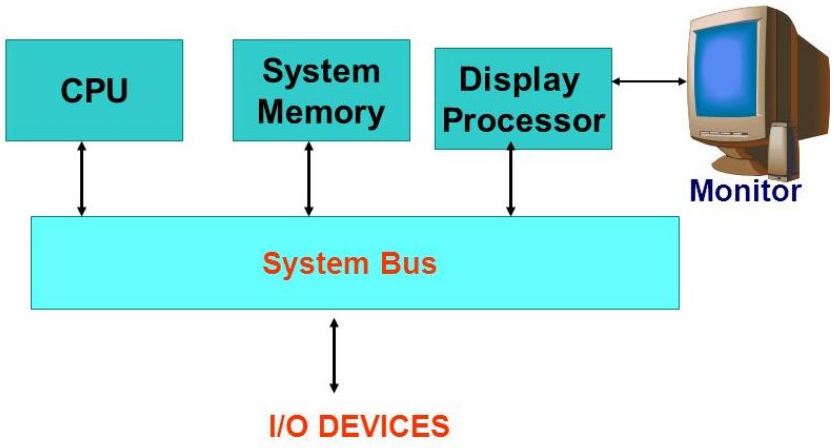


Fig 2.7: Architecture of a simple random– scan system

- Developed in 60's and used as common display device until 80's.
- Consists of CPU, a display presser (DPU or graphics controller), a CRT monitor, system memory, peripheral devices.
- An application program is input and stored in the system memory along with a graphics package.
- Graphics commands in the application program are translated by graphics package into a display file stored in the system memory.
- The display list or file is then accessed by the display processor to refresh the screen.
- The display processor cycle through each command in the display file program once during every refresh cycle.

Flat Panel Displays:

- Reduced volume, weight and power requirements compared to CRT.
- Current uses: TV monitor, calculator, pocket video games, laptop, armrest viewing of movies on airlines.

Two types:

i. Emissive displays
ii. Non–emissive displays

i. Emissive displays (emitter) :

- Emissive display are device that convert electrical energy into light energy.
  Eg. Plasma panel, LED, thin– film electroluminescent displays.

ii. Non–emissive display (Non–emitter) :

- Use optical effects to convert sun light or light from some other source into graphic pattern.
  Eg. LCD (Liquid crystal device)

Plasma panel :

- Also known as gas– discharge display.

- Region between two glass plates is filled with mixture of gases usually neon.
- A series of vertical conducting ribbons is placed on one glass plate and horizontal ribbons in another.
- Firing voltage is applied the pair of conductor to break down into glowing plasma of electrons and ions.
- Picture definition is stored to refresh buffer and firing voltage is applied to refresh the pixel position 60 times per second.
- Separation between pixels is provided by electric field of conductors.

Thin–film electroluminescent displays:

- Thin film electroluminescent display are similar in construction to a plasma panel. Filled with phosphor such as zinc sulfide doped with manganese instead of gas.
- When sufficiently high voltage is applied to a pair of crossing electrodes, the phosphor becomes a conductor in the area of the intersection of the two electrodes. Electrical energy is then absorbed by manganese atoms which release the energy as spot of light to glowing plasma affect in p.p.

LED:

- A matrix of diodes is arranged to form the pixel positions in the display and picture.
- Information is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light patterns in the display.

LCD: (Liquid Crystal Displays)

- Commonly used in small systems, such as calculators, and portable, laptop computers.
- These non–emissive devices produce a picture by passing polarized light from the surroundings or from an interval light source through a liquid crystal material that can be aligned to either block or transmit the light.