Unit 1

Introduction to Computer Graphics

Computer Graphics

- Computer Graphics is a field related to the generation of graphics using computers.
  - It deals with generating images with the aid of computers.
- Graphics are created using computers and the representation of image data are done by computer specifically with help from specialized graphic hardware and software.
- It is concerned with digitally synthesizing and manipulating visual content.
- It includes the creation, storage, and manipulation of images of objects.
- These objects come from diverse fields such as physical, mathematical, engineering, architectural, abstract structures and natural phenomenon.

Computer Graphics: Tasks

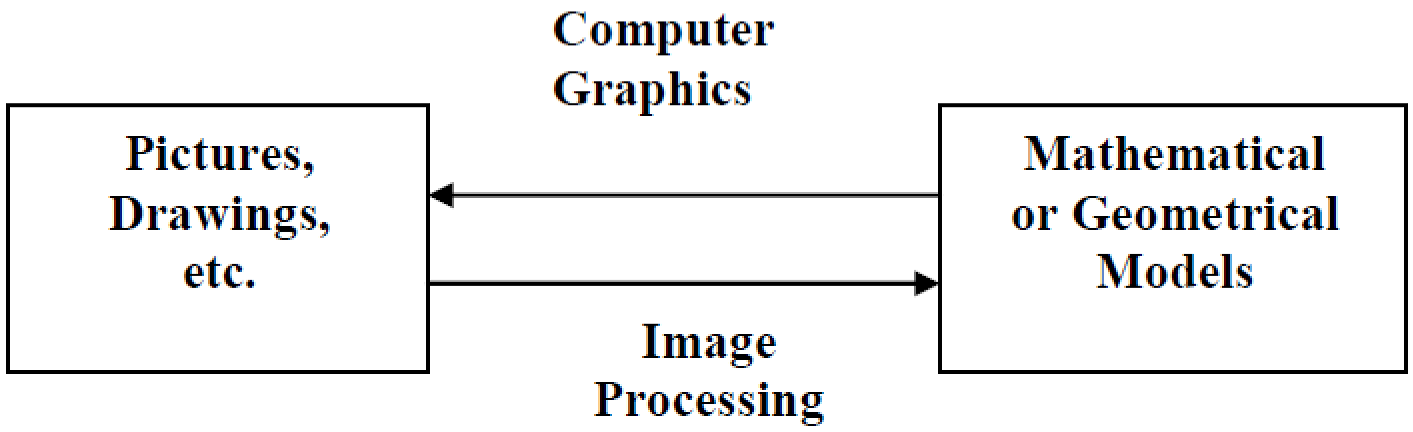
- **Imaging:**
    - Formation of an image.
    - representation of 2D images.
- **Modelling:**
    - Representing 3D images.
- **Rendering:**
    - Constructing 2D images from 3D models.
- **Animation:**
    - Stimulating changes over time.
    - describing how objects change in time.

Computer Graphics: Application

- Computational biology
- Computational photography
- Computational physics
- Computer-aided design
- Computer simulation
- Design
- Digital art
- Education
- Cartography
- Graphic design
- Infographics
- Information visualization
- Scientific visualization
- Special Effects for cinema
- Video Games
- Virtual reality
- Web design

Computer Graphics Vs Image Processing

- **Computer graphics**
  - It involves in generating images from mathematical or geometrical Models.
  - Eg: Drawing a picture
- **Image Processing**
  - It involves in analyzing the images to generate mathematical or geometrical model.
  - Eg: blurring an image.



Computer Graphics:

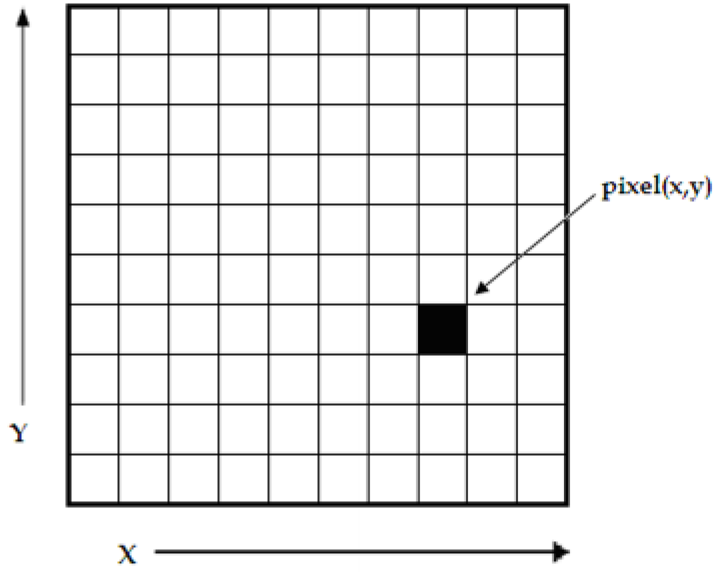
Synthesize pictures from mathematical or geometrical models.

Image Processing:

analyze pictures to derive descriptions (often in mathematical or geometrical forms) of objects appeared in the pictures.

Computer Graphics: Terminologies

- Pixel (picture element)
  - A pixel is the smallest element of a graphics display or the smallest element of a rendered image.
  - One dot or picture element of the raster



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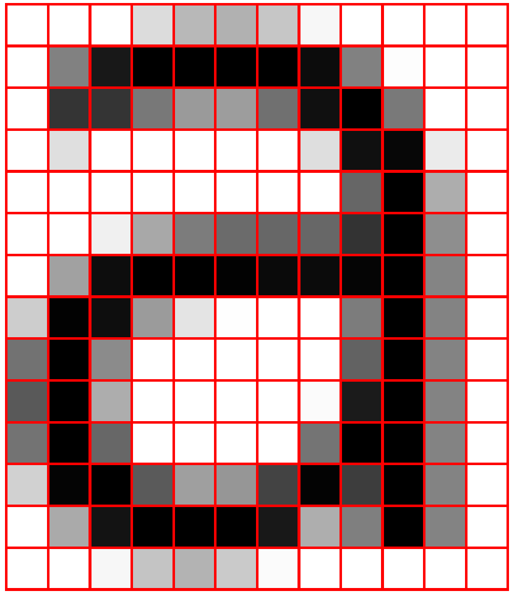

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1.0	0.2	0.2	0.5	0.6	0.6	0.5	0.0	0.0	0.5	1.0	1.0
1.0	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.0	0.0	0.9	1.0
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1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.4	0.0	0.5	1.0
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0.9	0.0	0.0	0.6	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
0.5	0.0	0.6	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
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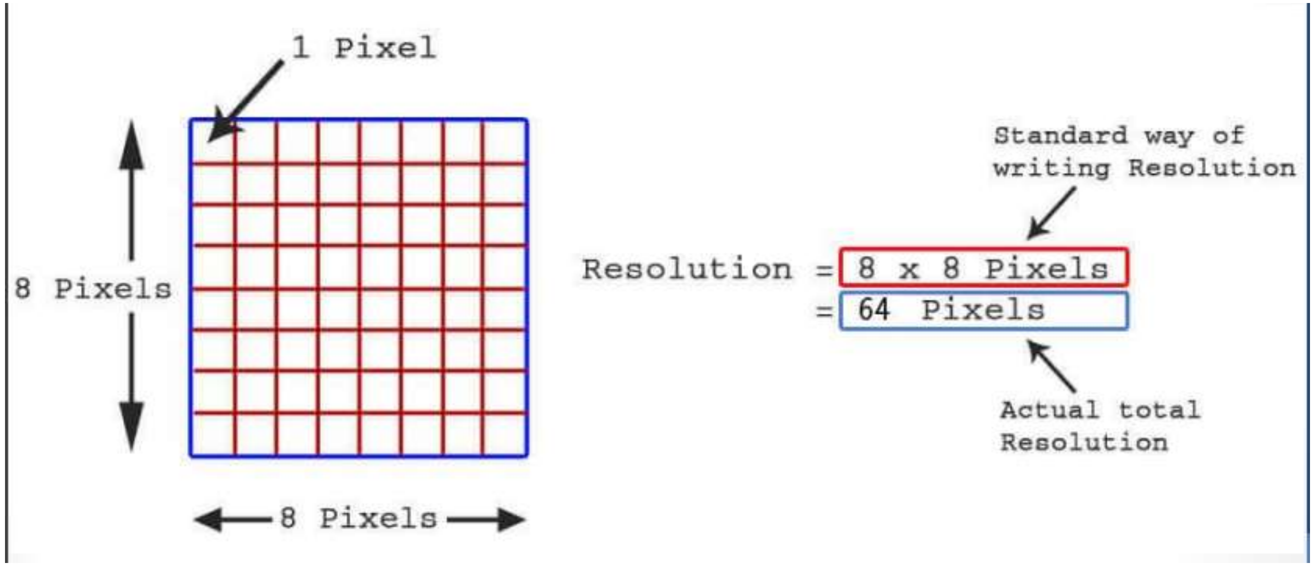
0.6	0.0	0.6	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.5	1.0
0.9	0.1	0.0	0.6	0.7	0.7	0.5	0.0	0.5	0.0	0.5	1.0
1.0	0.7	0.1	0.0	0.0	0.0	0.1	0.9	0.8	0.0	0.5	1.0
1.0	1.0	1.0	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0

Computer Graphics: Terminologies

- Resolution
  - Resolution is defined as the maximum member of points that can be displayed horizontally and vertically without overlap on a display device.
  - It refers to the total number of count of pixels in an digital image. For example.
  - If an image has M rows and N columns, then its resolution can be defined as M X N.



- If we define resolution as the total number of pixels, then pixel resolution can be defined with set of two numbers.
- The first number the width of the picture, or the pixels across columns, and the second number is height of the picture, or the pixels across its width.

- We can say that the higher is the pixel resolution, the higher is the quality of the image.
- We can define pixel resolution of an image as 4500 X 5500.

- Here’s a quick overview of the most common resolutions:
- • SD: 480p / 576p
- • HD: 720p / 1080p
- • 4K: 2160p
- • 8K: 4320p

Computer Graphics: Terminologies

- Aspect Ratio
  - The aspect ratio of an image describes the proportional relationship between its width and its height.
  - It is commonly expressed as two numbers separated by a colon, as in x:y.
  - In, for example, a group of images that all have an aspect ratio of 16:9, one image might be 16 inches wide and 9 inches high, another 16 centimeters wide and 9 centimeters high, and a third might be 8 yards wide and 4.5 yards high.

Computer Graphics: Terminologies

- Persistence
  - It means how long they continue to emit light after the electron beam is removed.
  - Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity.
  - Lower persistence phosphors require higher refresh rates to maintain a picture on the screen.
  - A phosphor with lower persistence is useful for animation and a higher–persistence phosphor is useful for displaying highly complex static picture.
  - Graphics monitor are usually constructed with the persistence 10 to 60 microseconds.

Computer Graphics:

Synthesize pictures from mathematical or geometrical models.

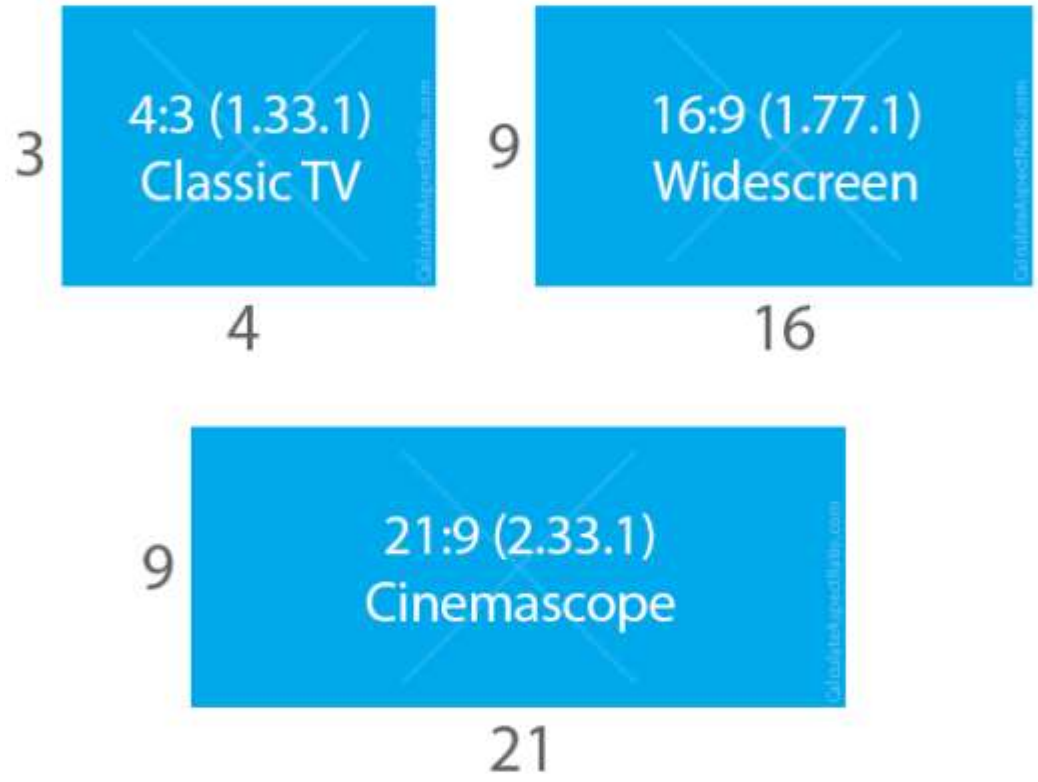
Image Processing:

analyze pictures to derive descriptions (often in mathematical or geometrical forms) of objects appeared in the pictures.

Computer Graphics: Terminologies

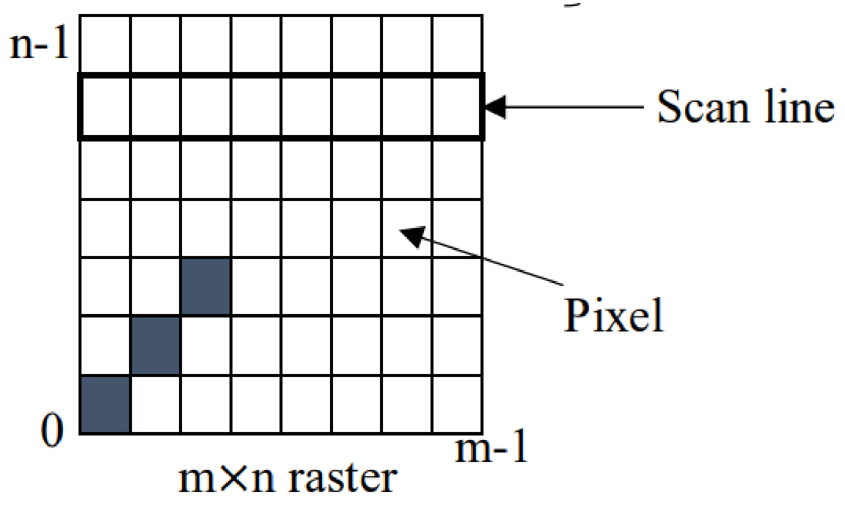
- Refresh rate
  - The number of times the screen is redrawn each second.
  - Higher refresh rates mean less flicker on the screen, which translates into less eyestrain.
  - It is measured in Hertz (Hz) or cycles per second.
  - As an example, a refresh rate of 60 Hz means the screen is redrawn 60 times per second. Higher refresh rates reduce or eliminate image "flicker" that can cause eye strain.

Popular Aspect Ratio



Computer Graphics: Terminologies

- RASTER :
  - A rectangular array of points or dots.
- SCAN LINE :
  - A row of pixels
- BITMAP :
  - ones and zeros representation of the rectangular array points on screen
  - bitmap : Black and white
  - Pixmap : color (colored raster image)



Computer Graphics: Terminologies

- 2D Graphics
  - Displayed representation of a scene or an object along two axes of reference: height and width (x and y).
- 3D Graphics
  - Displayed representation of a scene or an object that appears to have three axes of reference: height, width, and depth (x, y, and z).
- Animation
  - A technique providing the illusion of movement using a sequence of (rendered) still images.

Computer Graphics: Terminologies

- Buffer
  - Memory dedicated to a specific function or set of functions.
  - For example: the graphics memory functions as a frame buffer, but can also be used as a Z buffer or a video buffer.
  - Smaller buffers exist in many different places inside the display controller's memory as well and serve as temporary storage areas for data (e.g. bitmaps).
- Clipping
  - This usually means avoiding the drawing of items outside a defined field of view (e.g. in 2D a rectangular area).

Computer Graphics: Terminologies

- Frames per Second (FPS)
  - The rate at which the graphics processor renders new frames, or full screens of pixels.
  - Benchmarks and games use this metric as a measurement of a display controller's performance.
  - A faster display controller will render more frames per second, making the application more fluid and responsive to user input.
- Graphics Controller / Graphics Processor / Graphics Processing Unit (GPU)
  - A high-performance 2D or 3D processor that integrates the entire graphics pipeline (transformation, lighting, setup, and rendering).
  - A GPU offloads all calculations from the CPU, freeing the CPU for other functions such as physics and artificial intelligence.

Computer Graphics: Terminologies

- Lighting
  - Lighting is used to create realistic-looking scenes with greater depth instead of flat-looking or cartoonish environments.
  - One of many techniques for creating realistic graphical effects to simulate a real-life 3-D object on a 2-D display.
- Occlusion
  - The effect of one object in 3-D space blocking another object from view.
- OpenGL
  - A graphics API that was originally developed by Silicon Graphics, Inc.(SGI) for use on professional graphics workstations.
  - OpenGL subsequently grew to be the standard API for CAD and scientific applications and today is popular for consumer applications such as PC games as well. OpenGL ES is the version for embedded systems.

Computer Graphics: Terminologies

- Polygon
  - The building blocks of all 2D or 3D objects (usually triangles) used to form the surfaces and skeletons of rendered objects.
- Projection
  - The process of reducing three dimensions to two dimensions for display is called Projection. It is the mapping of the visible part of a three dimensional object onto a two dimension screen.
- Rendering
  - Rendering or image synthesis is the process of generating a photorealistic or non-photorealistic image from a 2D or 3D model by means of a computer program.

The process of creating life-like images on a screen using mathematical models and formulas to add shading, color, and lamination to a 2D or 3D wireframe. Hence: Rendering Engine - the part of the graphics engine that draws 3D primitives, usually triangles or other simple polygons. In most implementations, the rendering engine is responsible for interpolation of edges and 'filling in' the triangle.

Graphics Hardware

Graphics Hardware

- Graphics hardware is computer hardware that enables computers to produce and show computer graphics.
- It works in conjunction with graphics software.
- Examples of graphics hardware are display devices, graphics cards, graphics processing units and motion capture hardware.

Input Devices

- Mouse,
- Touch Screen,
- Light Pen,
- Data Glove,
- Tablet (Digitizer),
- Bar Code Reader

Output Devices

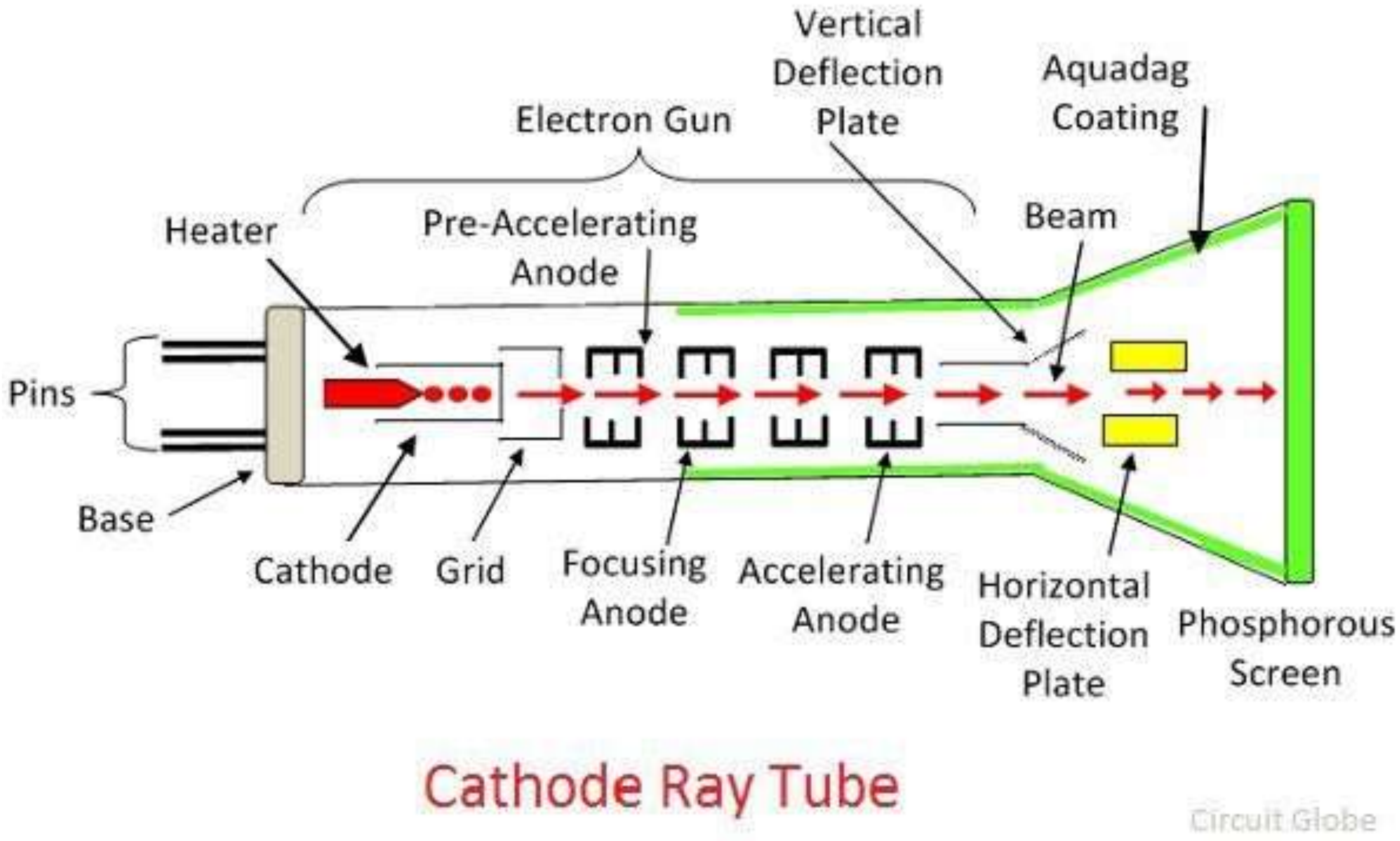
- Monitor
  - CRT
  - LCD
  - LED
  - Direct View Storage Tube(DVST)

CRT (Cathode Ray Tube)

- CRT are one of the display devices on computer.
- A CRT is an evacuated glass tube, with a heating element on one end and a phosphor-coated screen on the other end.
- When a current flows through this heating element (filament) the conductivity of metal is reduced due to high temperature.
- These cause electrons to pile up on the filament.
- These electrons are attracted to a strong positive charge from the outer surface of the focusing anode cylinder.
- These electrons are attracted by accelerating systems on the phosphor coated screen.
- When electron strikes on the screen, the phosphor emits a small spot of light at each position contacted by the electron beam.
- The glowing positions are used to represent the picture in the screen.

Persistence
Refresh rate

CRT (Cathode Ray Tube)



Cathode Ray Tube

An electron gun

- The primary components of an electron gun in a CRT are the heated metal cathode and a control grid.
- Heated metal cathode: Heat is supplied to the cathode by directing the beam through a coil of wire called the filament inside the cylindrical cathode structure.
- Control grid: Intensity of the electron beam is controlled by setting the voltage levels on the control grid, which is a metal cylinder that fits to the cathode.

- **Focusing System & Accelerating Anode**
  - The focusing system in a CRT is needed to force the electron beam to converge into a small spot as it strikes the phosphor.
  - And the accelerating anode is used to accelerate electron beam towards the phosphor coated screen. Otherwise, the electron beam would not reach to the screen.
- **Deflection System**
  - It is used to control the vertical and horizontal scanning of the electron beam.

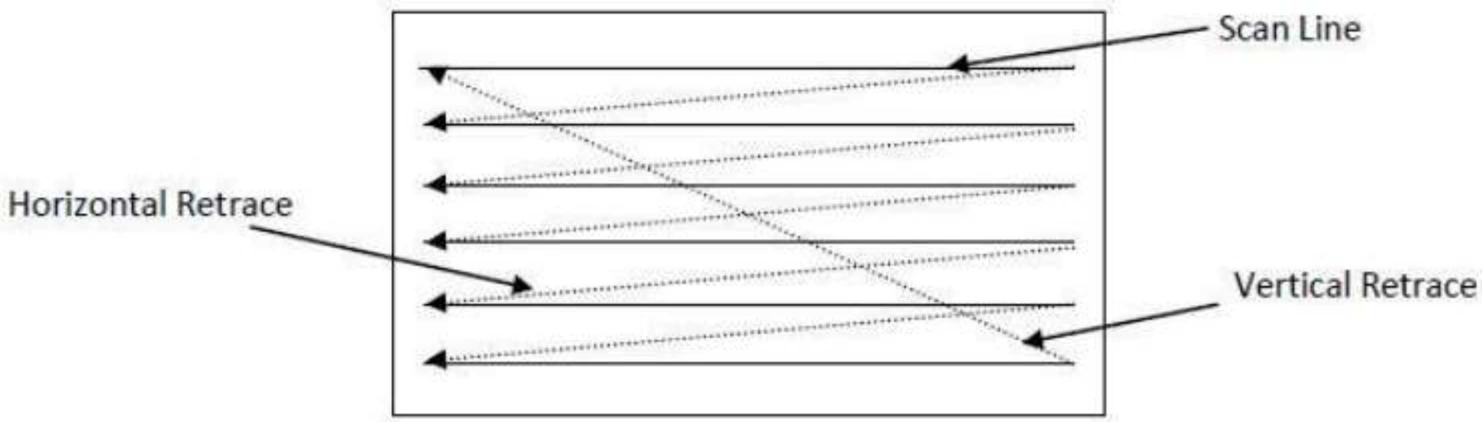
Display Technologies / Types of Refresh CRT

1. Raster-Scan Displays
2. Random-Scan Displays

Raster Scan Display

Raster Scan Display

- The most common type of graphics monitor employing a CRT is the raster-scan display.
- In raster scan approach, the viewing screen is divided into a large number of discrete phosphor picture elements, called pixels.
- Row of pixels is called the scan line. The matrix of pixels or collection of scan lines constitutes the raster (shown in figure below).



Raster Scan Display

- In raster scan system, the electron beam is swept across the screen, one row at a time from top to bottom.
- As electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.
- Picture definition is stored in memory called frame buffer or refresh buffer.
- This memory holds the set of intensity values for all the screen points.
- Stored intensity values are then retrieved from the frame buffer and painted on the screen one row at a time.
- Returning of electron beam from right end to left end after refreshing each scan line is called **horizontal retrace**.
- At the end of each frame, the electron beam returns to the top left corner to begin next frame called **vertical retrace**.

Raster Scan Display

- Two types of Raster-scan systems:
  1. Non-interlaced Raster-Scan System
  2. Interlaced Raster-Scan System

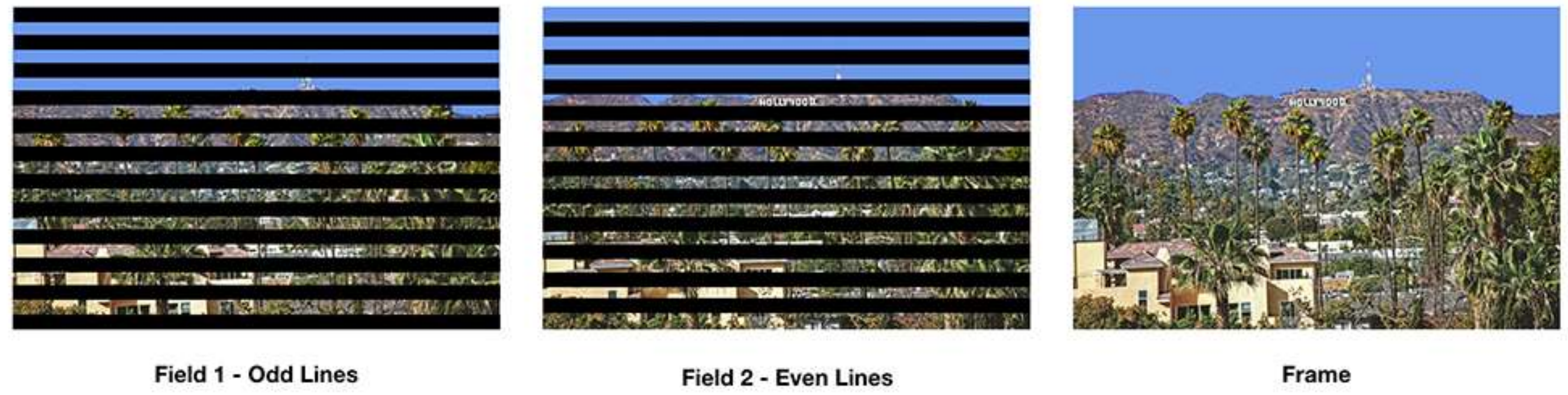
Interlaced Raster-Scan System

- In an **interlaced monitor,** the electron beam takes two passes to form a complete image:
  - it skips every other row on the first pass,
  - and then goes back and fills in the missing rows.

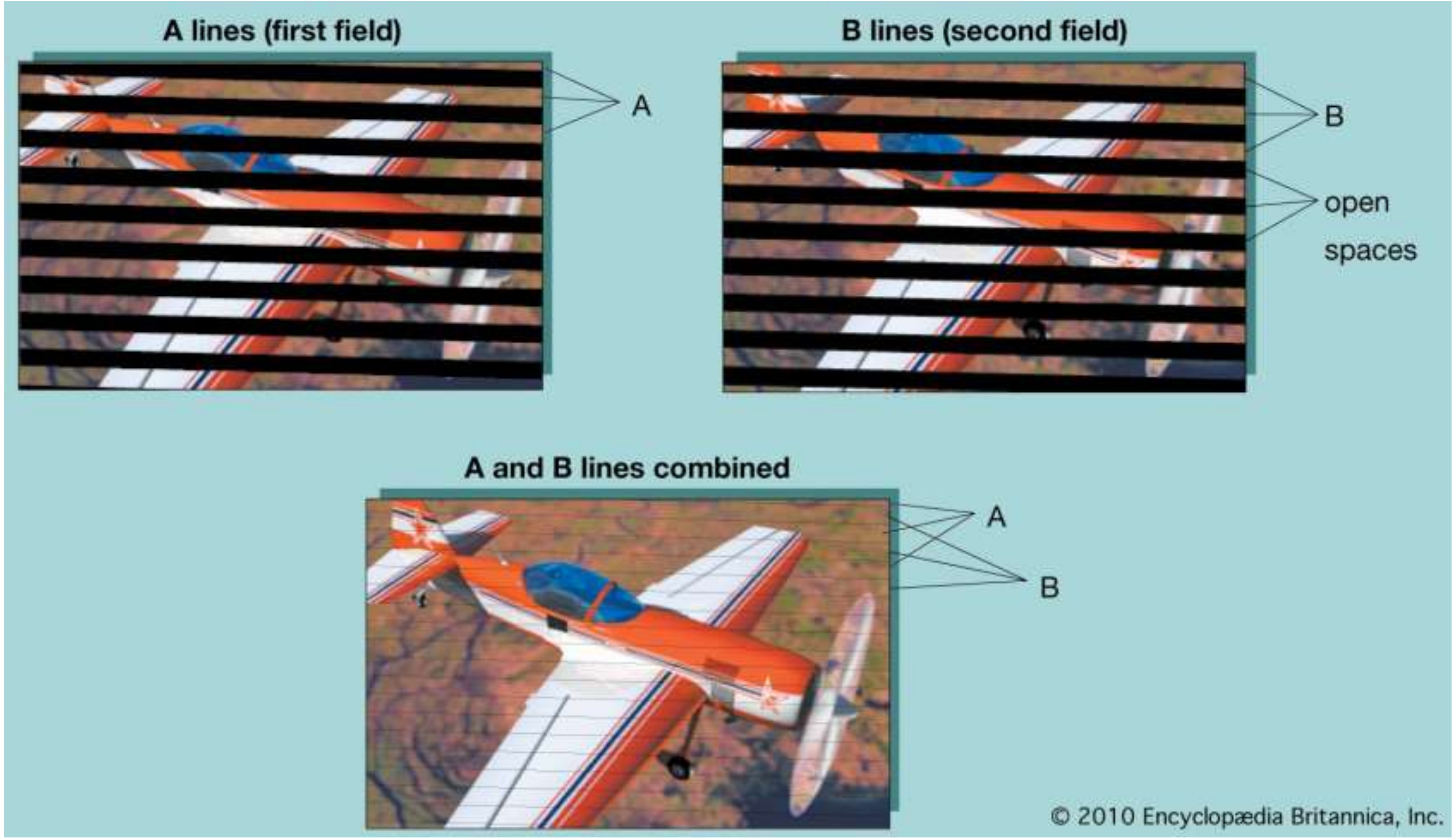
Interlaced Scan

- The problem is that all things being equal, it takes twice as long to create the complete screen image on an interlaced monitor. That’s long enough to spoil the illusion that you’re looking at a steady picture, and the image on the screen flickers annoyingly.

Interlaced Raster-Scan System

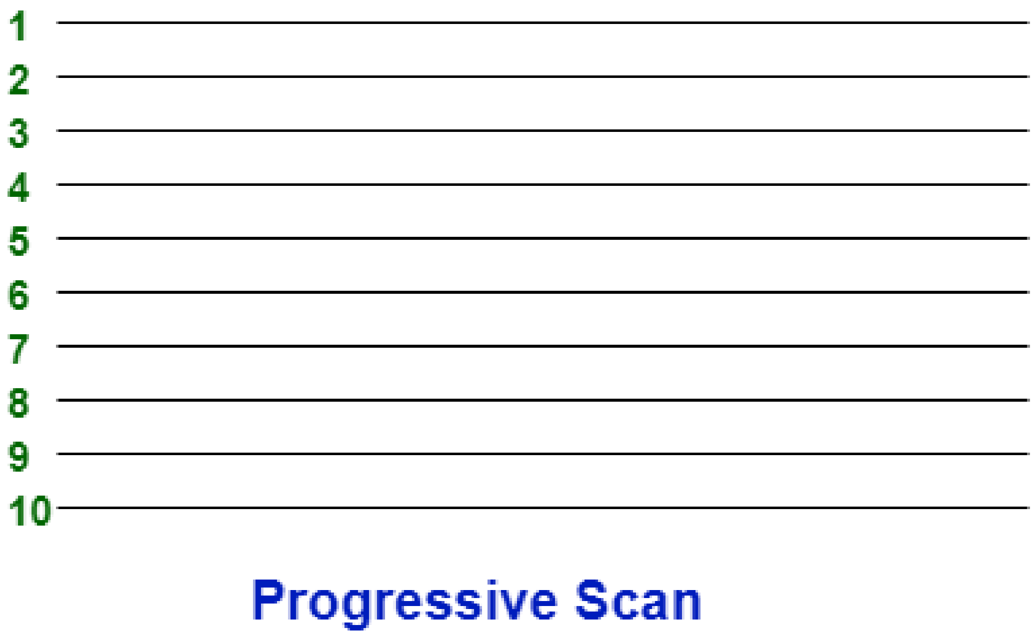


Interlaced Raster-Scan System



Non-interlaced Raster-Scan System

- A **non-interlaced monitor** does the whole job in one pass, tracing each row consecutively.



Interlaced Vs Non-interlaced Raster-Scan System

S.NO	Interlaced Scan	Non-interlaced Scan
1.	In interlaced scan, scanning takes place over dividing one frame.	While in non-interlaced scan, scanning takes place through scanning all frame promptly.
2.	Interlaced scan is less efficient than non-interlaced scan.	While non-interlaced scan is more efficient than interlaced scan.
3.	In interlaced scan, the displaying video speed is lesser than non-interlaced scan.	While in non-interlaced 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 non-interlaced scan.
5.	In interlaced scan, the video quality is vulgarized.	While in non-interlaced scan, the video quality is superior than interlaced scan.
6.	Interlaced scan is less promoted than non-interlaced scan.	While non-interlaced scan is more promoted than interlaced scan.

Architecture of Raster Scan display system:

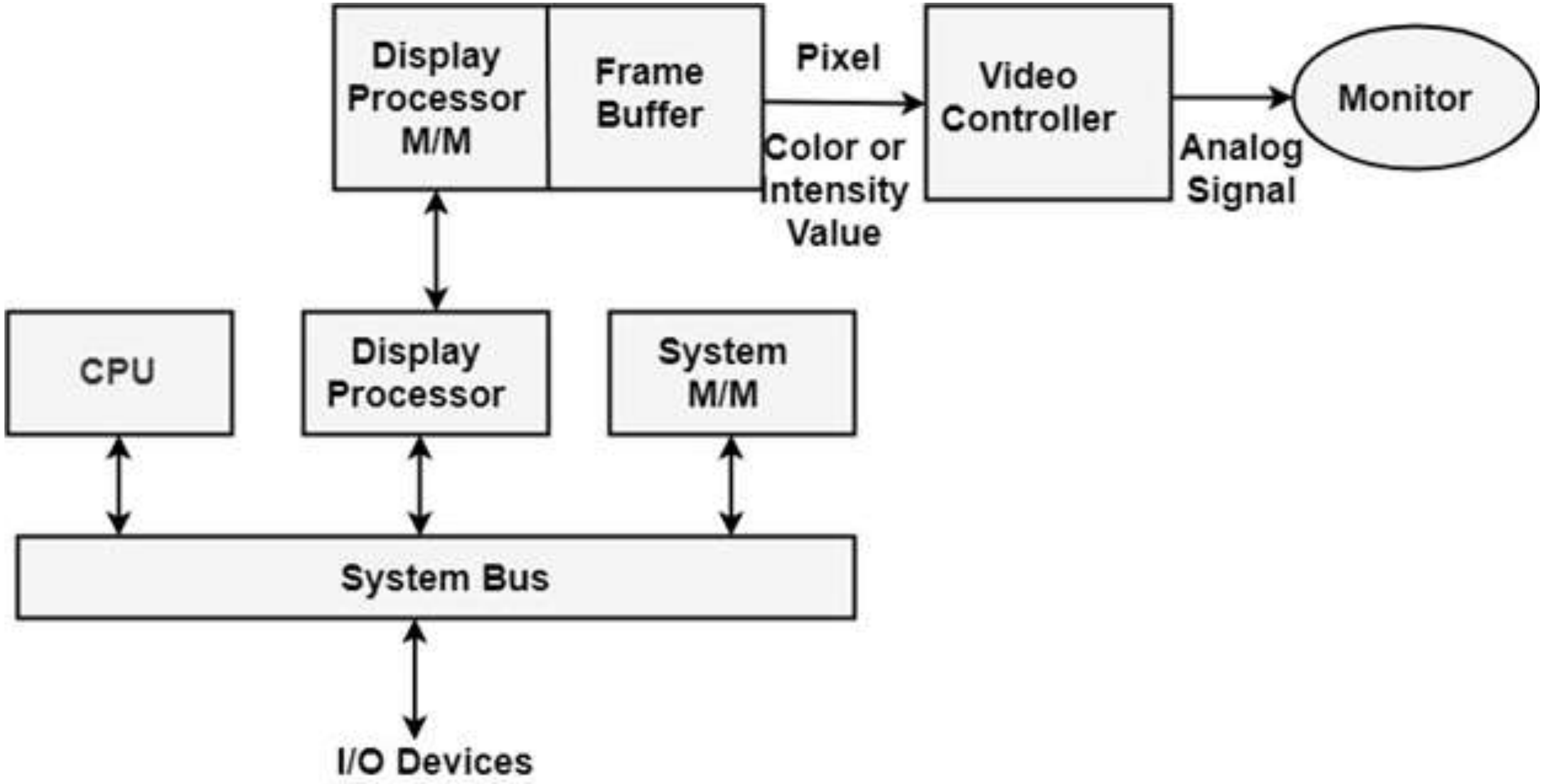


Fig: Architecture of a Raster Display System with a Display Processor

Several Units of Raster Scan display system:

- **CPU** is the main processing unit of computer systems.
- Besides CPU, graphics system consists of a special purpose processor called **display processor**.
- The **display processor** has its own separate memory called display processor memory.
  - System memory holds data and those programs that execute on the CPU, and the application program, graphics packages and OS.
  - The **display processor memory** holds data plus the program that perform scan conversion and raster operations.
  - The **frame buffer** stores displayable image created by scan conversion and raster operations.

Display Processor

- The purpose of the display processor or graphics controller is to free the CPU from the graphics chores/jobs.
- A major task of the display processor is digitizing a picture definition given in an application program into a set of pixel-intensity values for storage in the frame buffer.
- This digitization process is called scan conversion.

Lines and other geometrical objects are converted into set of discrete intensity points.

Characters can be defined with rectangular grids, or they can be defined with curved outlines.

Several Units of Raster Scan display system:

- **Frame Buffer,** a special area of memory is dedicated to graphics which holds set of intensity values for all the screen points.
  - The display image is stored in the form of 1’s and 0’s.
  - That intensity is retrieved from frame buffer and display on screen one row at a time.
- **Display Controller** (**video controller**) controls the operation of the display device.
  - The video controller has the direct access to the frame buffer for refreshing the screen.
  - The **video controller** reads this refresh buffer and produces the actual image on screen.

Raster Scan display system: Working

- It will scan one line at a time from top to bottom & then back to the top.
- In this method, the horizontal and vertical deflection signals are generated to move the beam all over the screen.
- Here, beam is swept back & forth from left to the right.
- When beam is moved from left to right it is ON.
- When beam is moved from right to left it is OFF and process of moving beam from right to left after completion of row is known as **Horizontal Retrace.**
- When beam is reach at the bottom of the screen. It is made OFF and rapidly retraced back to the top left to start again and process of moving back to top is known as **Vertical Retrace.**
- The screen image is maintained by repeatedly scanning the same image. This process is known as **Refreshing of Screen**.

Architecture of Raster Scan display system:

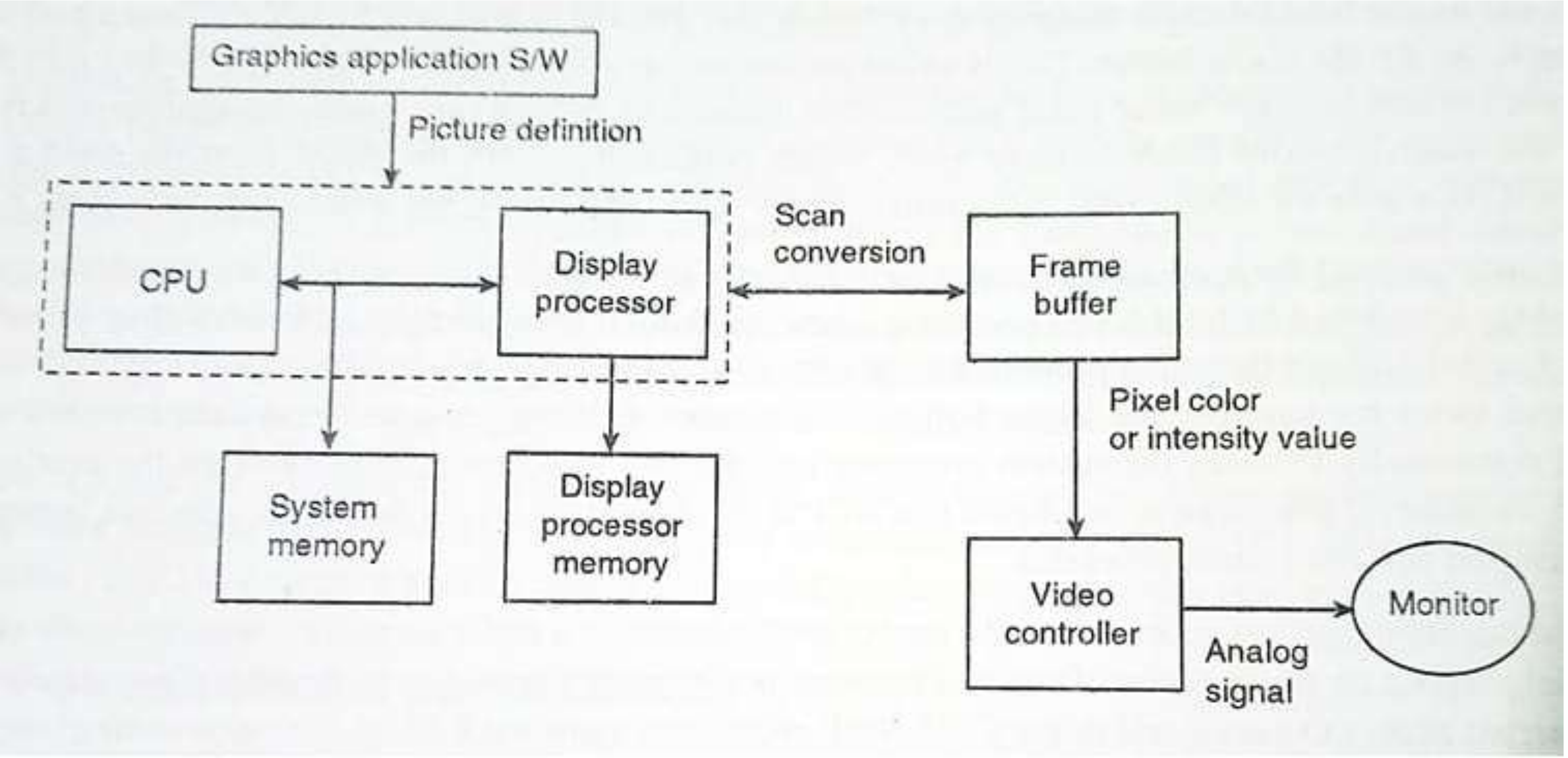
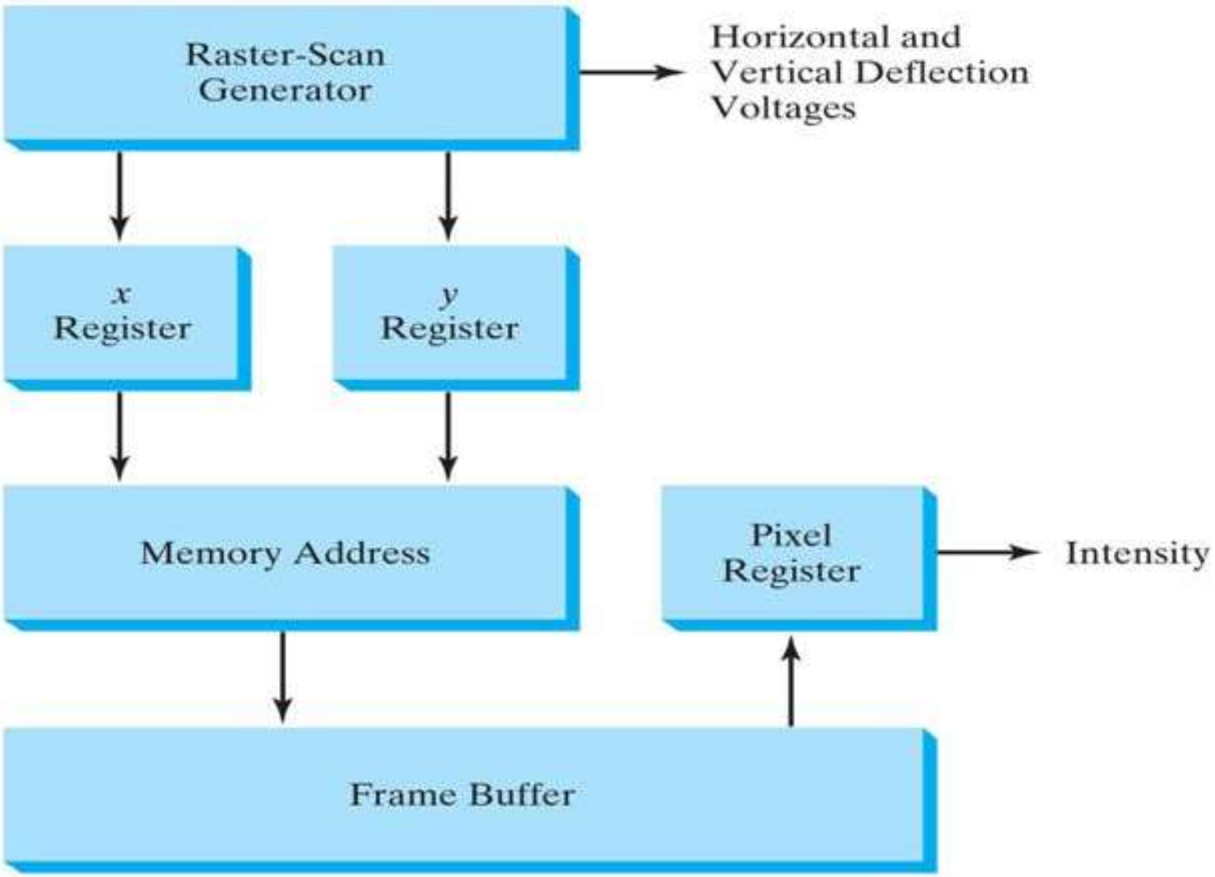
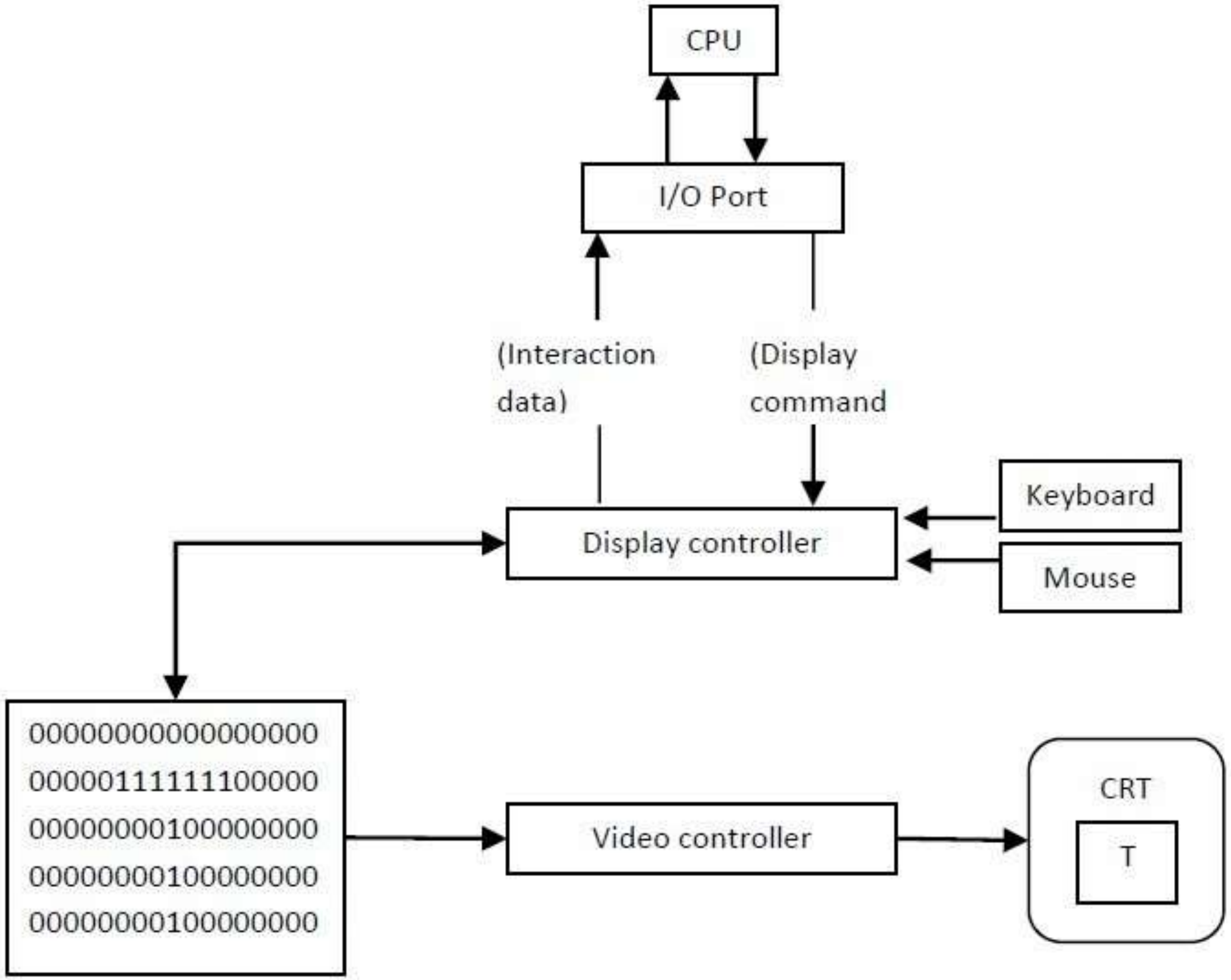


Fig: Architecture of Raster Scan Display

Raster Video Controller



Architecture of Raster Scan display system:



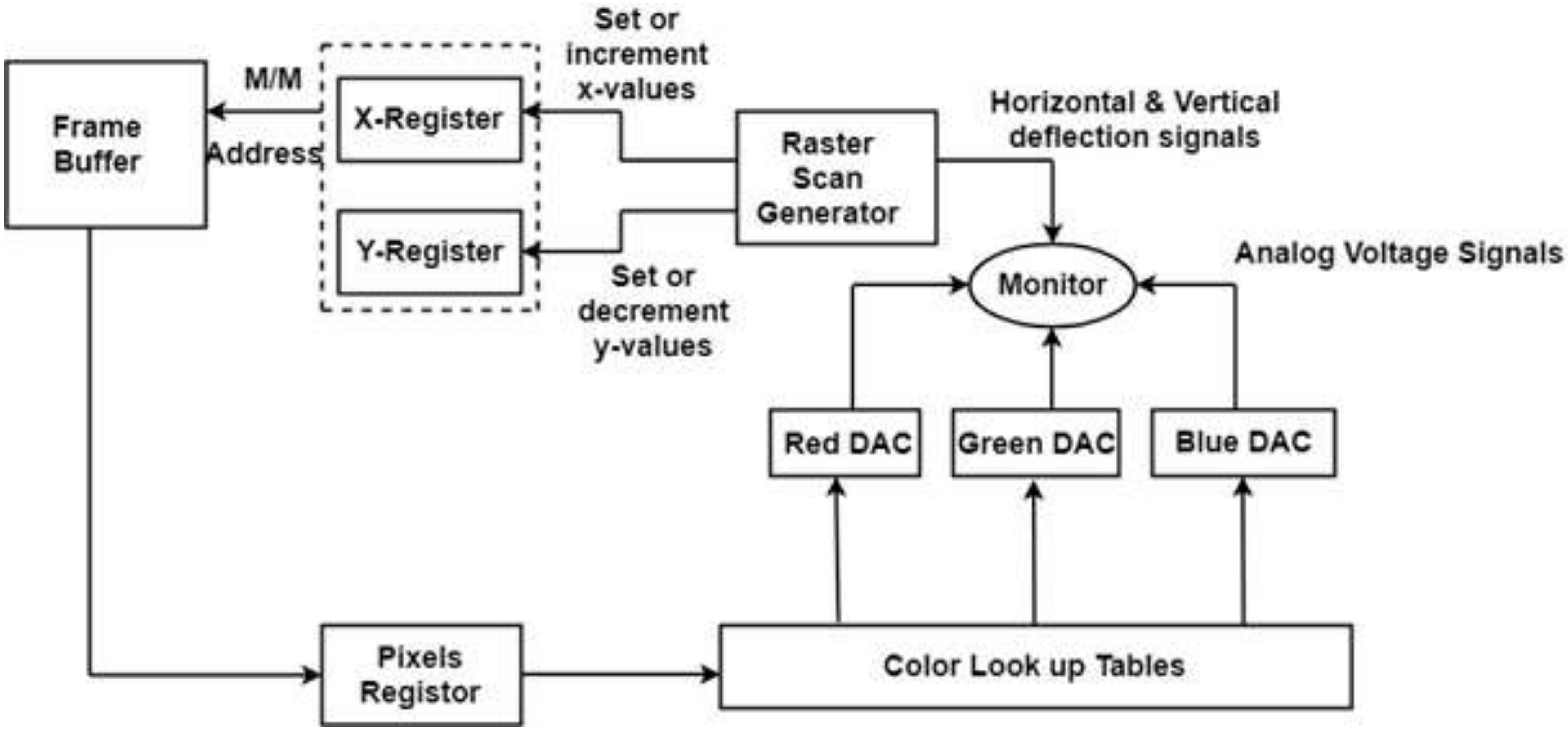
Architecture of Raster Scan display system:

- X register is set to 0 and y register is set to ymax.
- 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 xmax.
- 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.

Architecture of Raster Scan display system:

- 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.

Architecture of Raster Scan display system:



Raster Scan display: Advantages & Disadvantages

- **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
  - Real life images with different shades can be displayed.
  - Color range available is bigger than random scan display.

- **Disadvantages:**
  - Its resolution is poor.
  - More memory is required.
  - 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.
    - Data about the intensities of all pixel has to be stored.

Random/Vector Scan Display

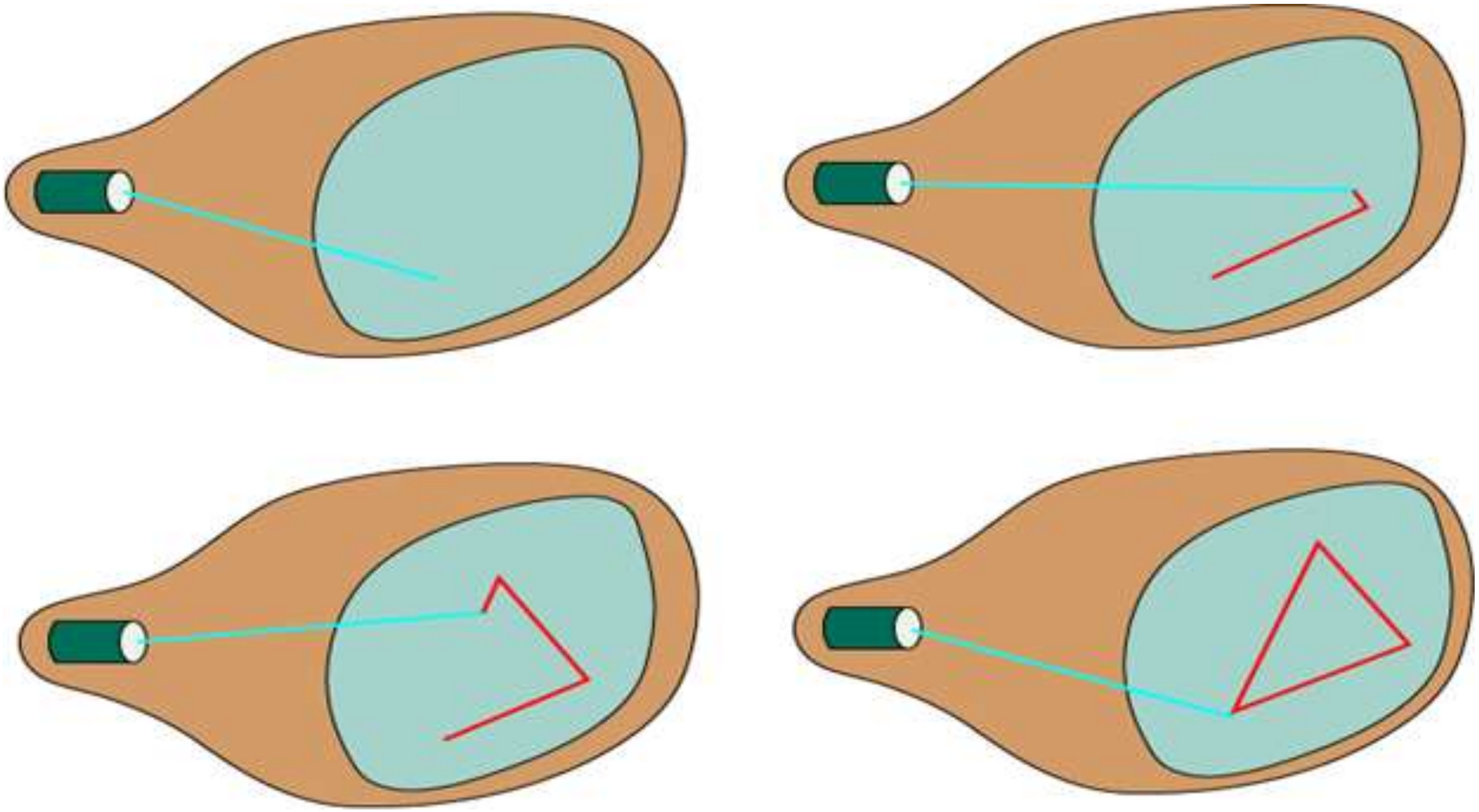
Random Scan display

- In this technique,
  - the electron beam is directed only to the part of the screen where the picture is to be drawn
  - rather than scanning from left to right and top to bottom as in raster scan.
- Picture definition is stored as a set of line-drawing commands in an area of memory referred to as the **refresh display file**.
- Random-scan monitors draw a picture one line at a time and for this reason are also referred to as **vector displays** (or **stroke-writing** or **calligraphic displays**).
- Random scan system uses an electron beam which operates like a pencil to create a line image on the CRT. The component line can be drawn or refreshed by a random scan display system in any specified order.

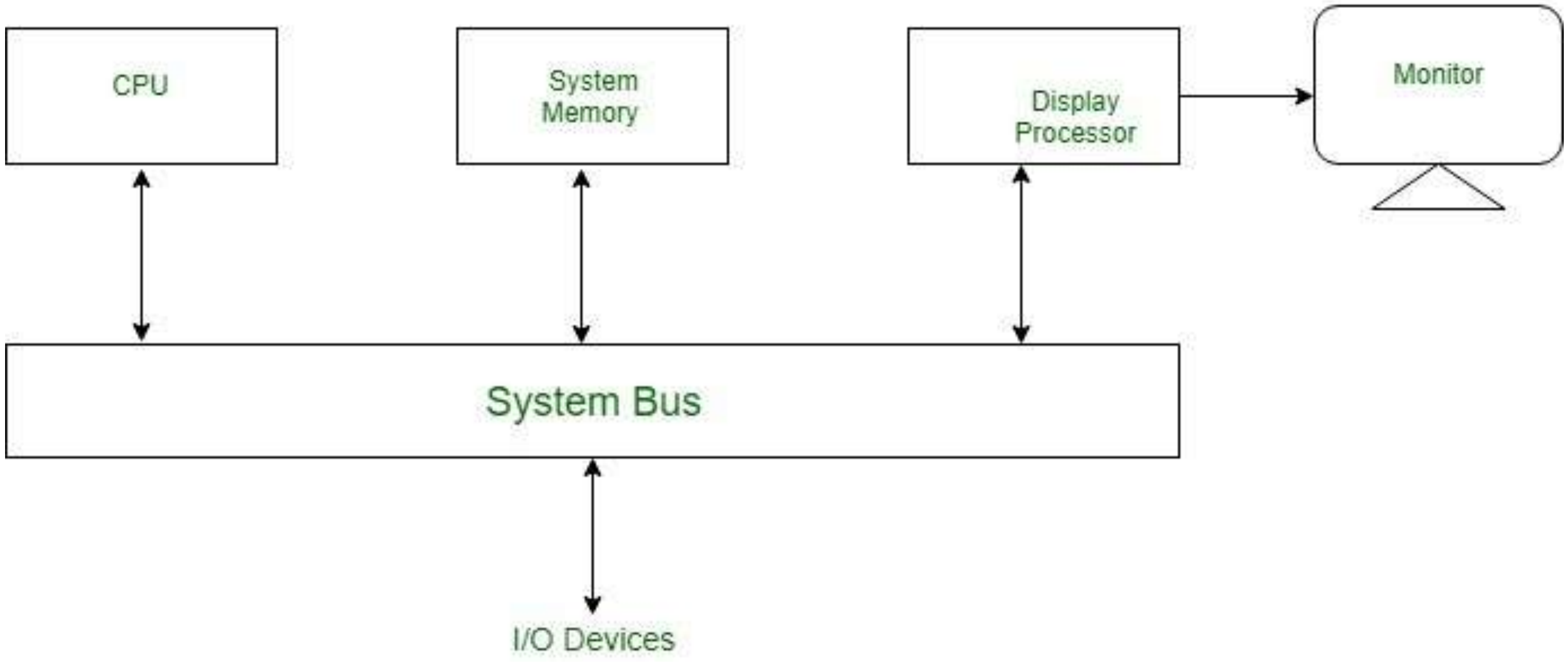
Random Scan display

- Random scan display directly traces out only the desired lines on CRT.
- If we want line between point p1 & p2 then we directly drive the beam deflection circuitry which focus beam directly from point p1 to p2
- If we do not want to display line from p1 to p2 and just move then we can blank the beam as we move it.
- To move the beam across the CRT, the information about both **magnitude** and **direction** is required.
- This information is generated with the help of **vector graphics generator**.
- Pen plotter is an example of random-scan displays.

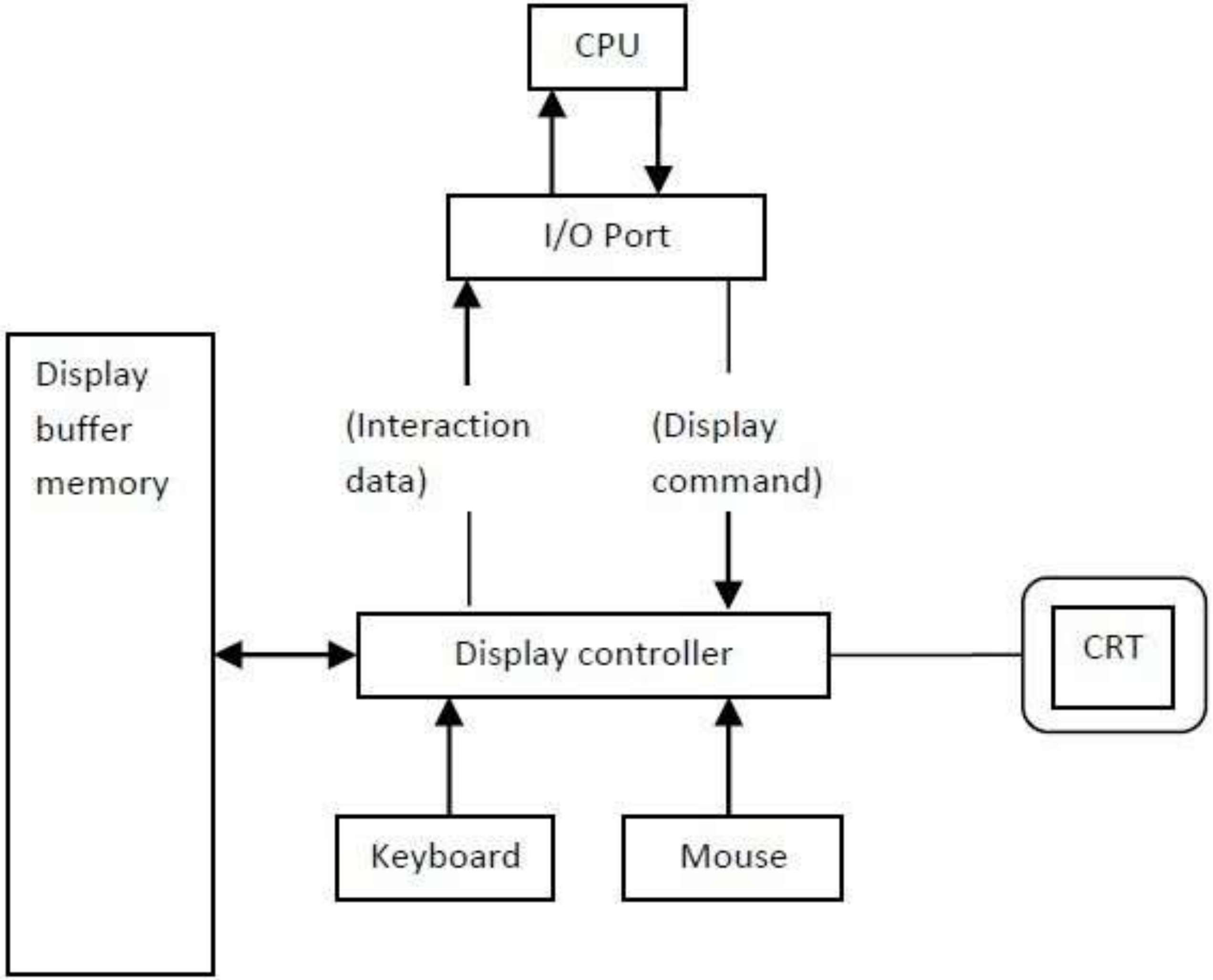
Random Scan display



Architecture of a vector display



Architecture of a vector display



Architecture of a vector display

- It consists of
  - display controller,
  - CPU,
  - display buffer memory and
  - CRT.
- **Display controller** is connected as an I/O peripheral to the CPU.
- **Display buffer** stores computer produced display list or display program.
- The Program contains point & line plotting commands with end point co-ordinates as well as character plotting commands.
- **Display controller** interprets command and sends digital and point co-ordinates to a vector generator.

Architecture of a vector display

- **Vector generator** then converts the digital co-ordinate value to analog voltages for beam deflection circuits that displace an electron beam which points on the CRT's screen.
- In this technique, beam is deflected from end point to end point hence this techniques is also called random scan.
- We know as beam strikes phosphors coated screen it emits light but that light decays after few milliseconds and therefore it is necessary to repeat through the display list to refresh the screen at least 30 times per second to avoid flicker.
- As display buffer is used to store display list and used to refreshing, it is also called **refresh buffer**.

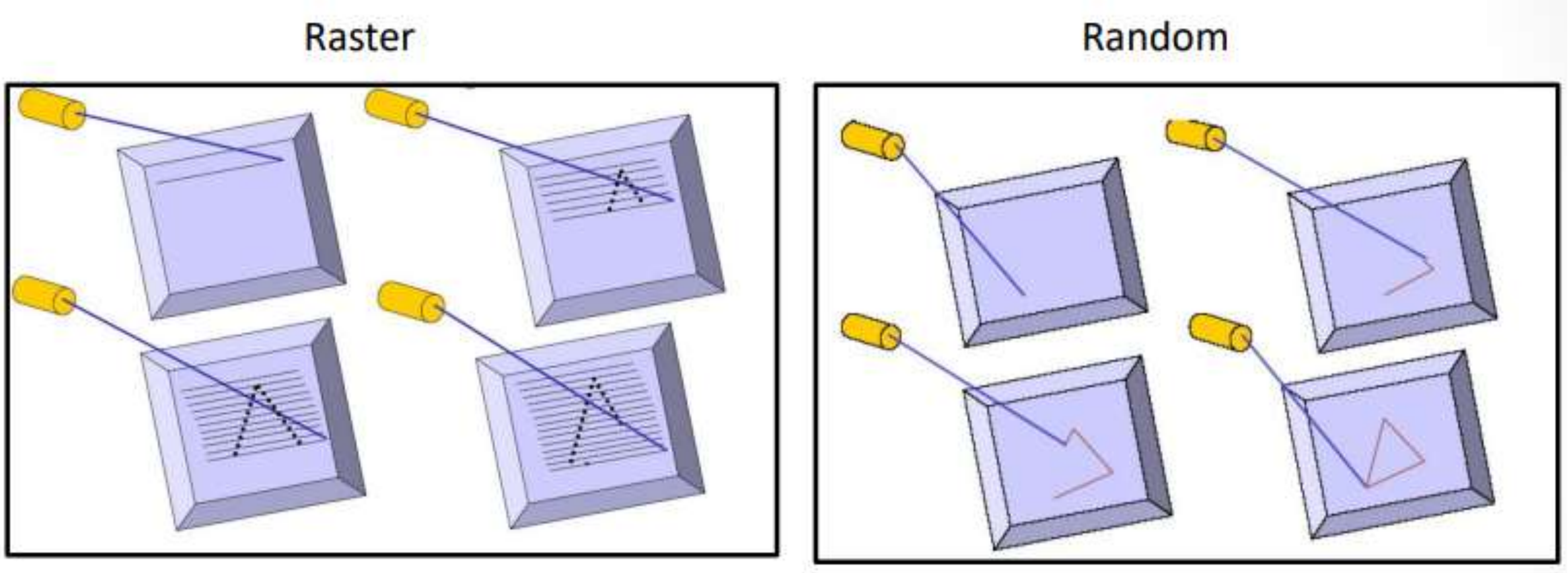
Working of a vector display

- Input in the form of an application program is stored in the system memory along with graphics package.
- Graphics package translates the graphic commands in application program into a display file stored in system memory.
- This display file is then accessed by the display processor to refresh the screen.
- The display processor cycles through each command in the display file program.
- Sometimes the display processor in a random-scan is referred as *Display Processing Unit / Graphics Controller*.

Advantages & Disadvantages: Vector display

- **ADVANTAGES:**
  - A CRT has the electron beam directed only to the parts of the screen where an image is to be drawn.
  - Higher resolution as compared to raster scan display.
  - Produces smooth line drawing.
  - Less Memory required.
- **DISADVANTAGES:**
  - As area with pattern and manipulate bits cannot be filled, Realistic images with different shades cannot be drawn.
  - Color limitations.
  - Refreshing image depends upon its complexity.

Raster Vs Random



Color CRT

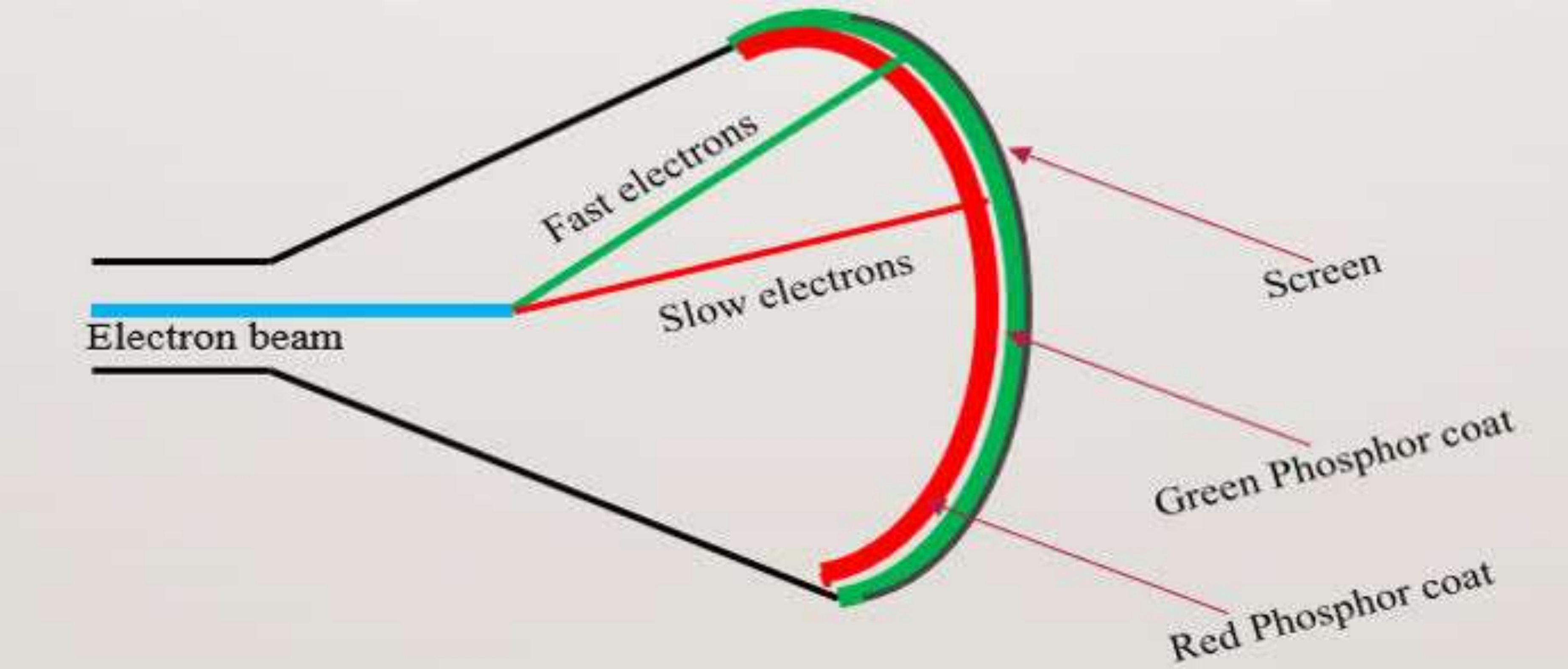
Color CRT

- A color CRT monitor displays color pictures by using a combination of phosphors that emit different-colored light.
- By combining the emitted light from the different phosphors, a range of colors can be generated.
- Two basic technique for producing color display with CRT are:
  1. Beam penetration method.
  2. Shadow-mask Method.

Beam Penetration Method

- It is a cheaper method and is used in Vector scan displays.
- In this method the inside section of CRT is coated with red (outer layer) and green (inner layer) phosphors.
- If the electrons are slow they penetrate only the outer layer thus emitting red light,
- and if the electrons are moving fast they penetrate the outer layer and the inner layer.
- The electrons speed is also adjusted in such a way that by combination of red and green, orange and yellow color are also produced.
- The limitation of this method is that only four colors can be displayed in the screen. Since we have only four colors the quality of image is diminished.

Beam Penetration Method



Beam Penetration Method

- Advantages
  - Economical way to produce colors
- Limitations:
  - Quality of picture is not good as with other methods.
  - It is an inexpensive way to produce color in random scan monitors, but only four colors are possible.
  - A reliable technology to accelerate the electronic beam to precise levels to get the exact colors – it is easier said than done.

Shadow Mask Method

- This method is commonly used in raster scan systems because they can produce wide range of colors than beam penetration.
- The shadow mask CRT, instead of using one electron gun, uses 3 different guns placed one by the side of the other to form a triangle or a “Delta”.
- Each pixel point on the screen is also made up of 3 types of phosphors to produce red, blue and green colors.
- A shadow mask grid is installed just before the phosphor coated screen.
- The three electron beams are deflected and focused as a group onto the shadow mask, which contains a series of very fine holes aligned with the phosphor dot patterns.

Shadow Mask Method

- The metal holes focus the red beam onto the red color producing phosphor, green beam on the green producing one and blue beam on the blue producing one.
- Unlike the beam penetration CRTs where the acceleration of the electron beam was being monitored, we now manipulate the intensity of the 3 beams simultaneously.
- If the red beam is made more intense, we get more of red color in the final combination etc.
- Since fine-tuning of the beam intensities is comparatively simple, we can get much more combination of colors than the beam penetration case.

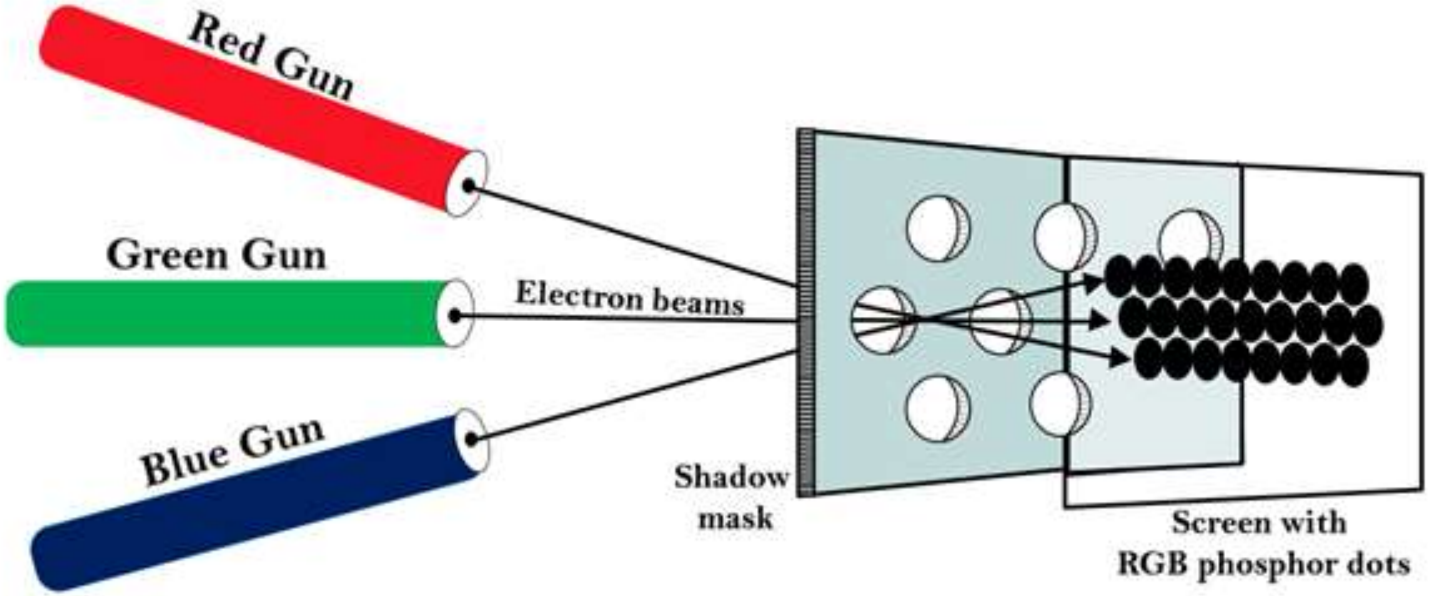
Shadow Mask Method

- Since three beams are to be focused, the role of the “Shadow mask” becomes critical.
- If the focusing is not achieved properly, the results tend to be poor.
- Also, since instead of one pixel point in a monochrome CRT now each pixel is made up of 3 points (for 3 colors), the resolution of the CRT (no. of pixels) for a given screen size reduces.
- Another problem is that since the shadow mask blocks a portion of the beams (while focusing them through the holes) their intensities get reduced, thus reducing the overall brightness of the picture.
  - To overcome this effect, the beams will have to be produced at very high intensities to begin with.
- Also, since the 3 color points, though close to each other, are still not at the same point, the pictures tend to look like 3 colored pictures placed close by, rather than a single picture. Of course, this effect can be reduced by placing the dots as close to one another as possible.

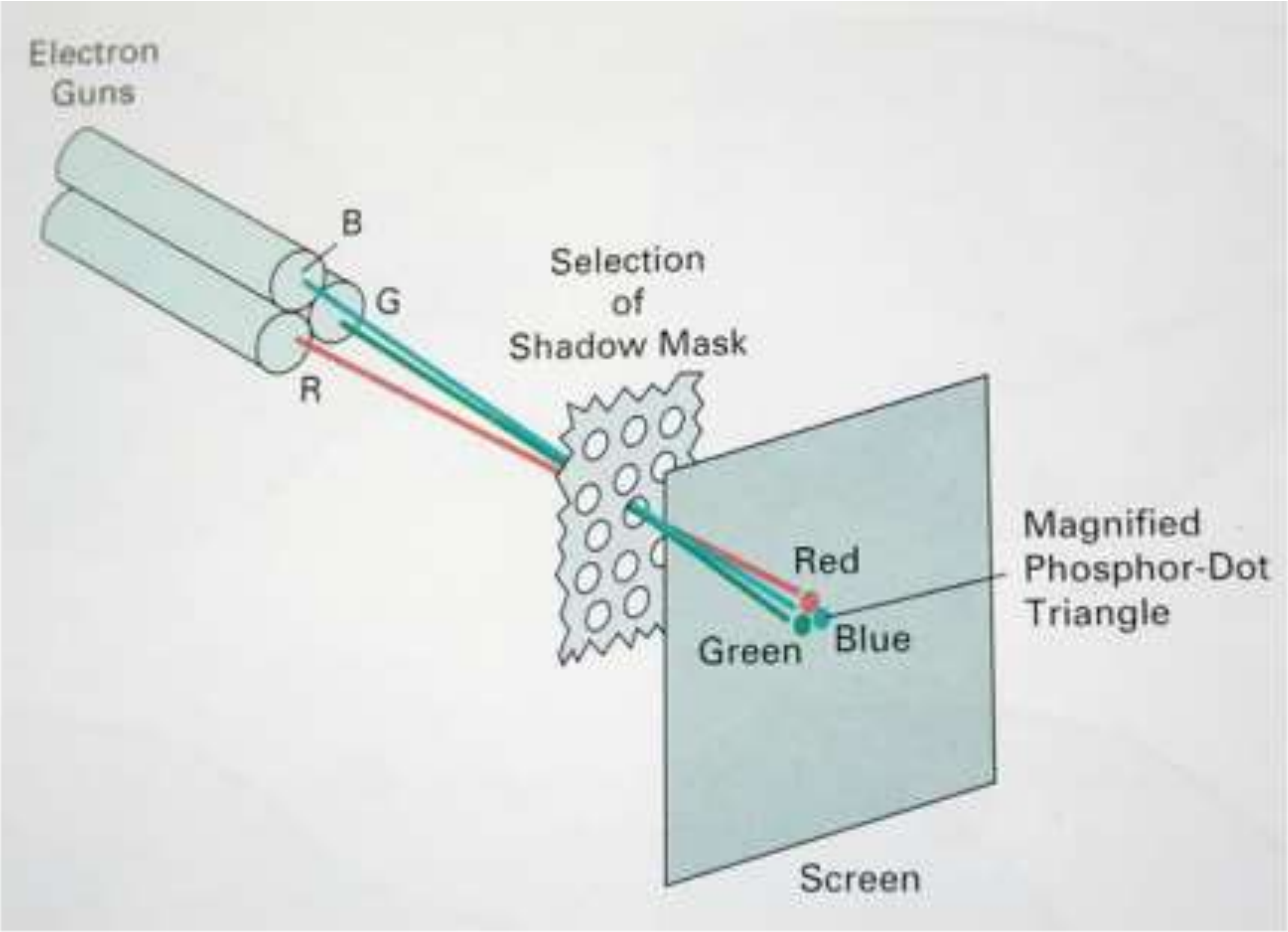
Shadow Mask Method

- These problems are partly overcome by devices with inherent storage devices – i.e. they continue to display the pictures, till they are changed or at least for several minutes without the need of being refreshed. We see one such device called the Direct View Storage Tube (DVST) below.

Shadow Mask Method



Shadow Mask Method



Shadow Mask

- A shadow mask is a metal sheet with holes punctured in a regular pattern that is present inside a color monitor.
- It is a part of a cathode-ray tube (CRT) setup where the electron beam, after generation from an electron gun source, is directed toward the screen to create images.
- The beam is focused by making it pass through the shadow mask.
- A shadow mask directs the electron beam by absorbing the electrons that are going in the wrong direction so that the beam only hits the desired points and the resulting picture is not blurred.
- It is the task of a shadow mask to direct each beam on its respective dot on the screen and form an intelligible picture on the screen.

Advantages & Disadvantages: Shadow Mask Method

- Advantage:
  - Realistic image
  - Million different colors to be generated
  - Shadow scenes are possible
- Disadvantage:
  - Relatively expensive compared with the monochrome CRT.
  - Relatively poor resolution
  - Convergence Problem

Numerical

Numerical

- There is a system with 24 bits per pixel and resolution of 1024 by 1024. Calculate the size of frame buffer.

Resolution = 1024 × 1024
Total number of pixel = 1024*1024 = 1048576 pixels
Per pixel storage = 24 bits

Total storage required in frame buffer = 1048576*24 = 25165824 bits
= 25165824/8 byte
= 25165824/(8*1024) kb
= 25165824/(8*1024*1024)Mb
= 3 Mb

Numerical

- Consider a RGB raster system is to be designed using 8 inch by 10 inch screen with a resolution of 100 pixels per inch in each direction. If we want to store 8 bits per pixel in the frame buffer, how much storage do we need for the frame buffer?

Size of screen = 8 inch × 10 inch
Pixel per inch (Resolution) = 100
Total no. of pixel = (8*100)*(10*100) = 800000 pixels
Per pixel storage = 8 bit

Total storage required in frame buffer = 800000*8 bits = 6400000 bits
= 6400000/8 bytes = 800000 byte