COMPUTER GRAPHICS

Section – II

Computer Graphics Devices

Computer Graphics Devices

- **Examples of Computer Graphics Devices:**
  - CRT, EGA/CGA/VGA/SVGA monitors,
  - Plotters, data matrix, laser printers, Films,
  - Flat panel devices, Video digitizers, scanners,
  - LCD panels, keyboard, joystick, mouse,
  - Touch screen, track ball, etc.
- **The most commonly used display device is the**
    - CRT monitor

Video Display Devices

- Primary output of the graphics system is a video monitor.
- The operation of most video monitors is based on standard cathode ray tube design.
- **Types of CRT display devices**
  - **DVST (Direct View Storage Tube)**
  - **Calligraphic or Random Scan display system**
  - **Refresh and Raster scan display system**

Cathode Ray Tube(CRT)

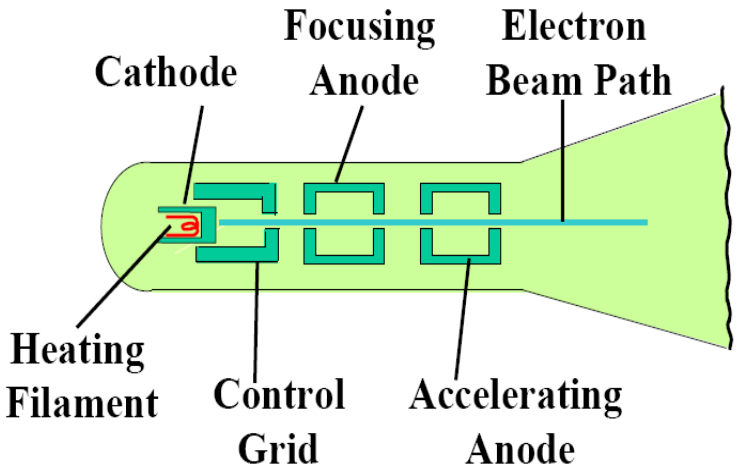
•Contains a filament , when heated, emits a stream of electrons.

•Electrons are focused with an electromagnet into a sharp beam and directed to a specific point of the face of the picture tube

•The front surface of the picture tube is coated with small phosphor dots.

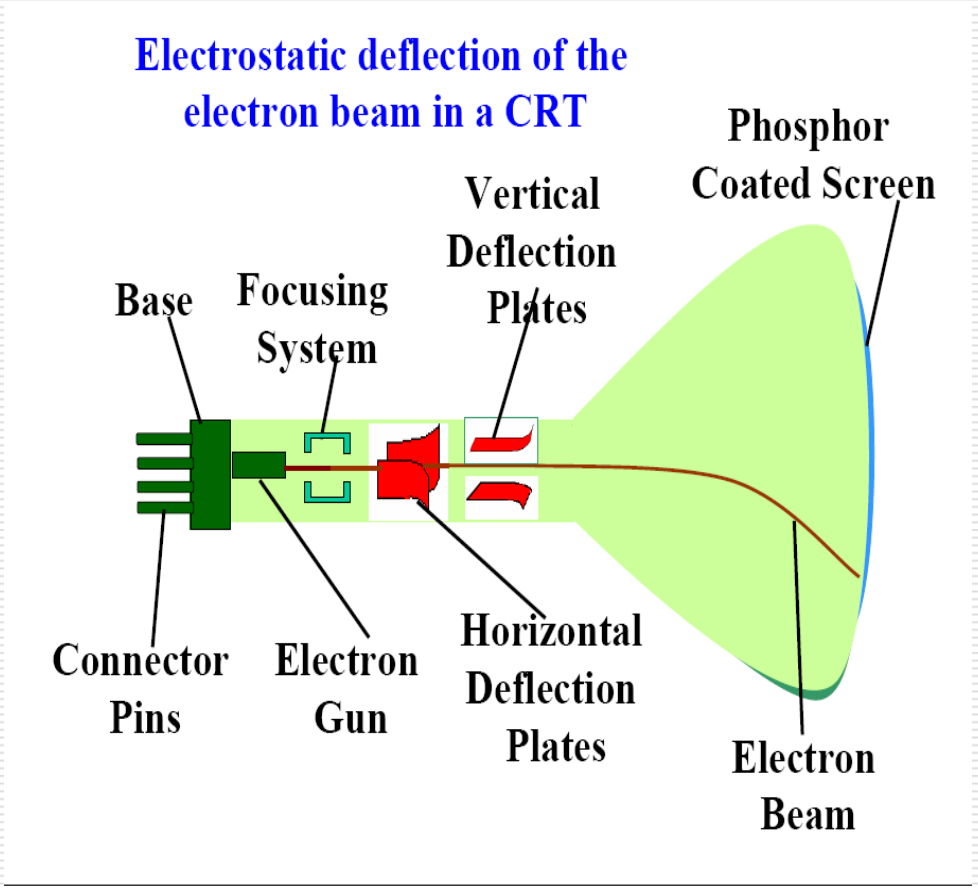
•When the beam hits a phosphor dot it glows with a brightness proportional to the strength of the beam and how long it takes to hit

Operation of an electron gun with an accelerating anode



CRT

- Intensity & Brightness controlled by voltage levels.
- Electron beam has to be focused only at the centre (Focusing system)
- Deflection directs the electron beam horizontally and vertically at any point on the screen
- Deflection controlled by pair of deflection plates.
- CRT beam energy (Heat + High quantum) +phosphor=light spot.
- Fading = Excited phosphor drop to ground state after some time.



CRT

- **Persistence**: Time taken by the emitted light to decay to 1/10th of its original intensity.
  - Lower persistence requires high refresh rates to maintain a picture without flicker.
  - High persistence phosphor is useful for displaying complex static pictures.
- **Resolution**: The total no of points that can be displayed without overlap on a CRT.
  - Depends on type of phosphor, the intensity to be displayed and focusing and deflection systems.
  - High definition systems has a resolution 1280*1024.
- **Aspect Ratio**: The ratio of horizontal points to vertical points needed to produce equal length lines in both directions on the screen.
- **Refresh Rate:** Rate at which the screen is refreshed.

CRT characteristics

- How can one measure CRT capabilities?
  - Size of tube
  - Brightness of phosphors vs. darkness of tube
  - Speed of electron gun
  - Width of electron beam
  - Pixels

Refresh and Raster scan display system

- Refresh CRT is a point-plotting device.
- The electron beam is swept across the screen, one row at a time from top to bottom.
- Each row is called as scan line.
- As it moves across each scan line, the intensity is turned on and off to create pattern of illuminated spots.
- Raster displays store the display primitives (lines, characters, shaded and patterned areas) in a refresh buffer
- Refresh buffer or Frame buffer stores the drawing primitives in terms of points and pixels components as intensity values.
- Used in television screens and printers.

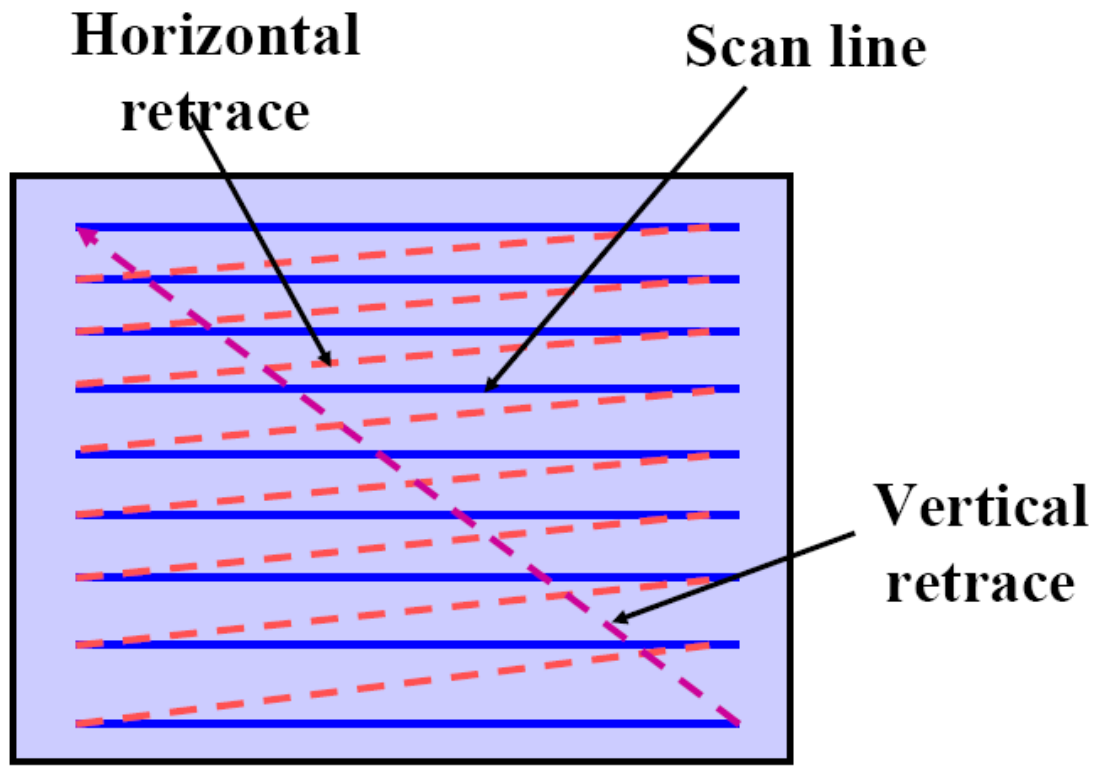
Refresh and Raster scan display system

- B/W system : 1 bit/pixel – intensity control
  - 1-> beam turned on
  - 0-> beam turned off
  - Frame buffer : Bit map
- Additional bits per pixel for color system.
  - Frame buffer :Pix map
- Needs 60 to 80 frames per second.
- **Horizontal Retrace**: After refreshing each scan line the electron beam return to the left of the screen .
- **Vertical Retrace**: At the end of each frame , beam returns to the top left corner of the screen to begin the next frame.

Refresh and Raster scan display system

- **Interlacing**: Allows us to see the entire screen displayed in ½ the time it would have taken to sweep across all the lines at once from top to bottom.
- **Interlaced Refresh procedure:**
  - To reduce flicker, divide frame into two “fields” of odd and even lines.
  - Divides into two passes.
    - 1st pass : Beam sweeps across every even scan lines from top to bottom.
    - 2nd pass : After vertical retrace, beam sweeps remaining odd scan lines.
  - Used with slow refresh rates.

Refresh and Raster scan display system



Refresh and Raster scan Display System

Interlacing

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  - 1st pass : Beam sweeps across every even scan lines from top to bottom.
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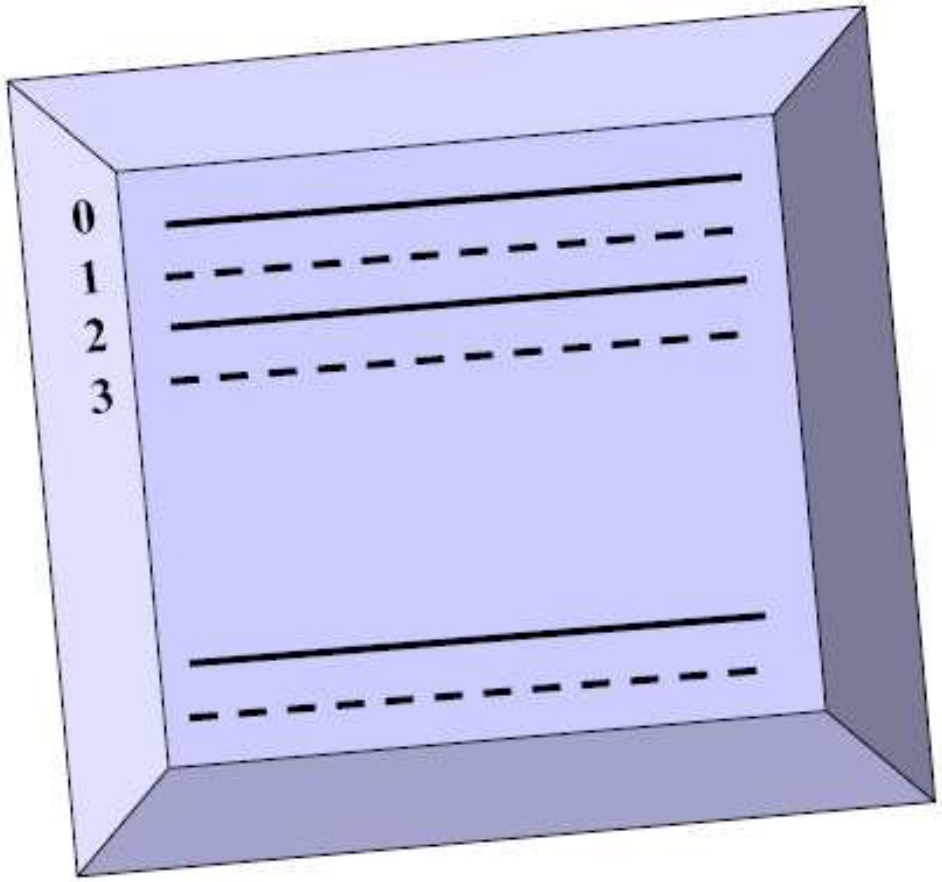
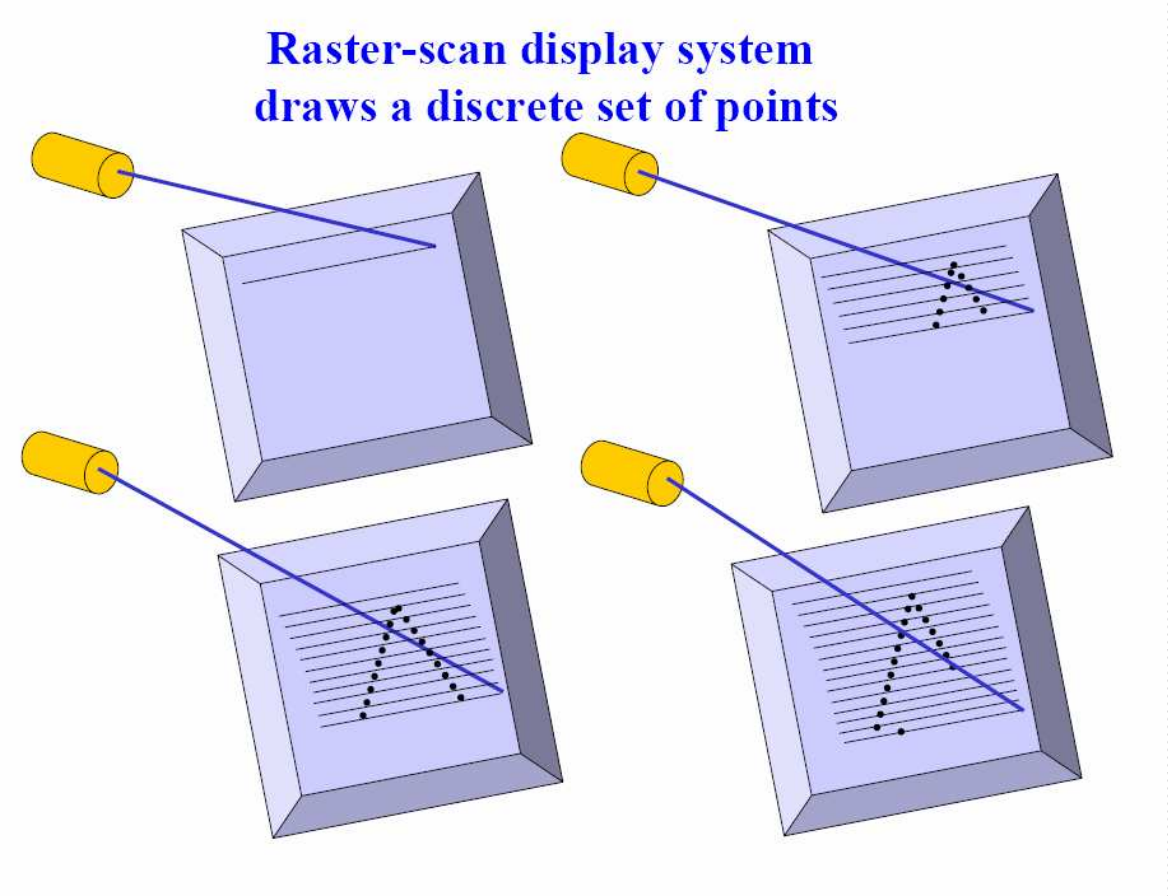
Interlacing



Raster-scan display system draws a discrete set of points



Basic video-controller refresh operations

•Video controller controls the operation of display devices.

•Frame buffer stores the drawing primitives in terms of intensity values.

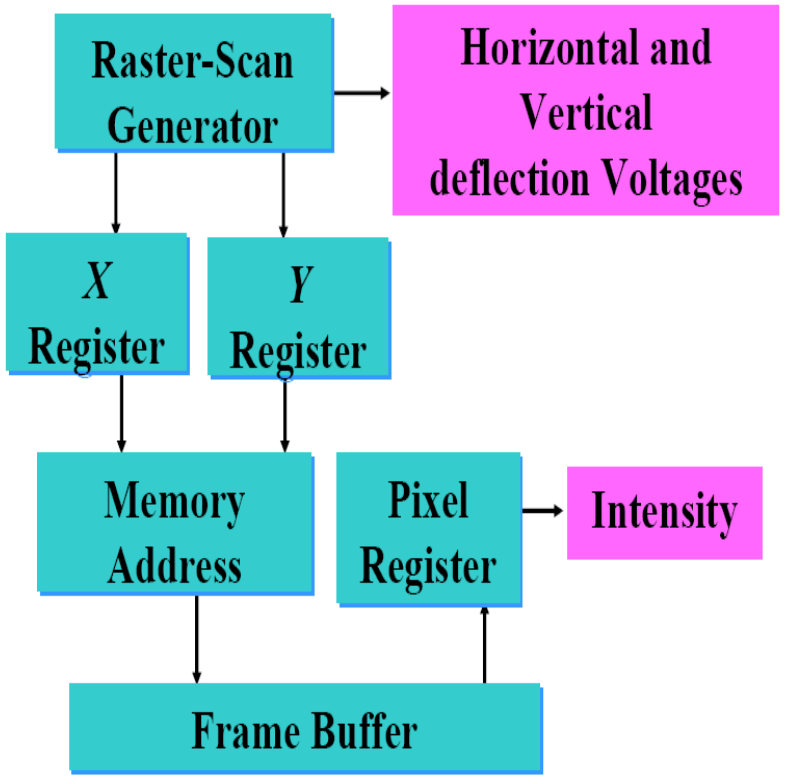
•Can be anywhere in the system memory

•VC access the frame buffer to refresh the screen

•Two registers used to store screen pixel coordinates.

- •Register X→0
- •Register Y→Ymax

•The value stored in the frame buffer for the pixel position is retrieved and used to set the intensity values.



Basic video-controller refresh operations

- For each scanline
  - X is incremented from left to right.
  - X reset to 0 and Y decremented by 1 after last pixel of the scan line.
  - The process repeated till the bottom scan line
- VC resets the registers to first pixel position to start refresh process.
- Screen refreshed at the rate of 60 frames/sec, cycle is too slow.
- To improve the refresh rate , multiple pixel intensities stored in separate register controls the beam intensity for adjacent pixels.
- Lookup table is also used to improve the refresh rate.

Architecture of a raster-graphics system with a display processor /Graphics Controller

•The purpose of the display processor to free the CPU from graphics chores.

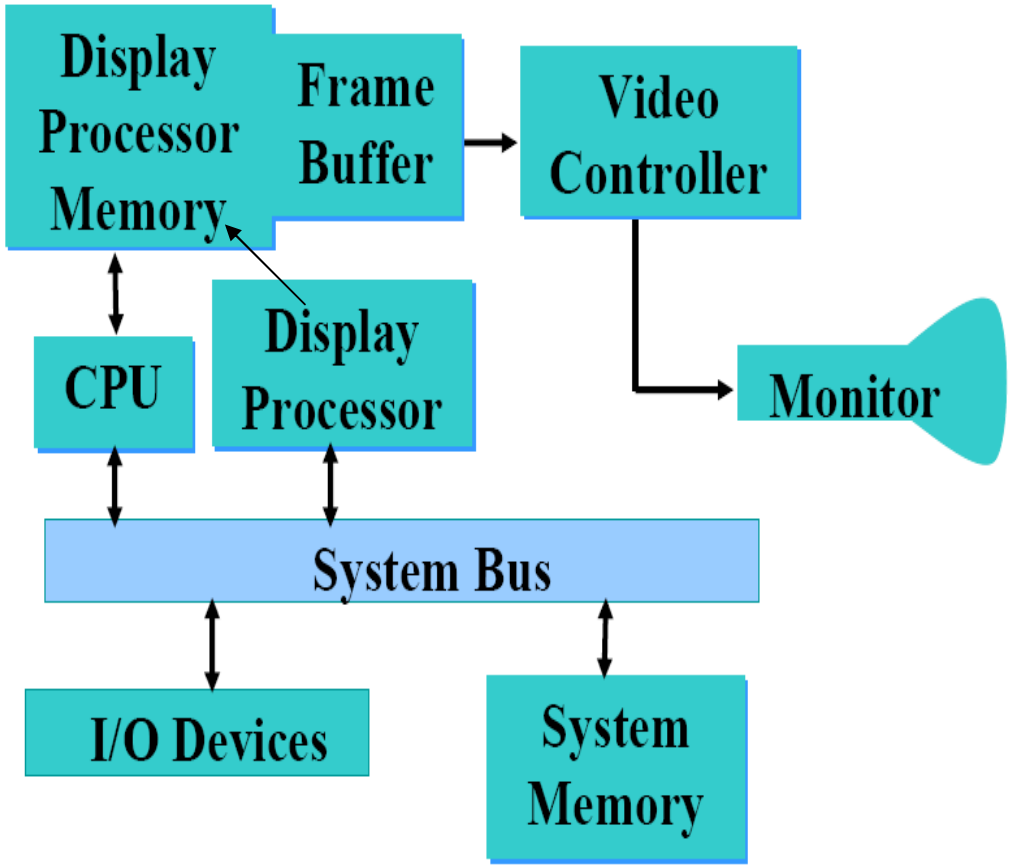
•The major task of the display processor is to digitizes the picture.

•Scan conversion :Digitizes a picture definition into a set of pixel intensity values for storage.

•Scan converting a straight line: locates pixel position closest to the line path and store the intensity for each position in frame buffer.

•Similar methods used for curved lines and polygon outlines.

•Characters- Rectangular grids/Curved outlines.



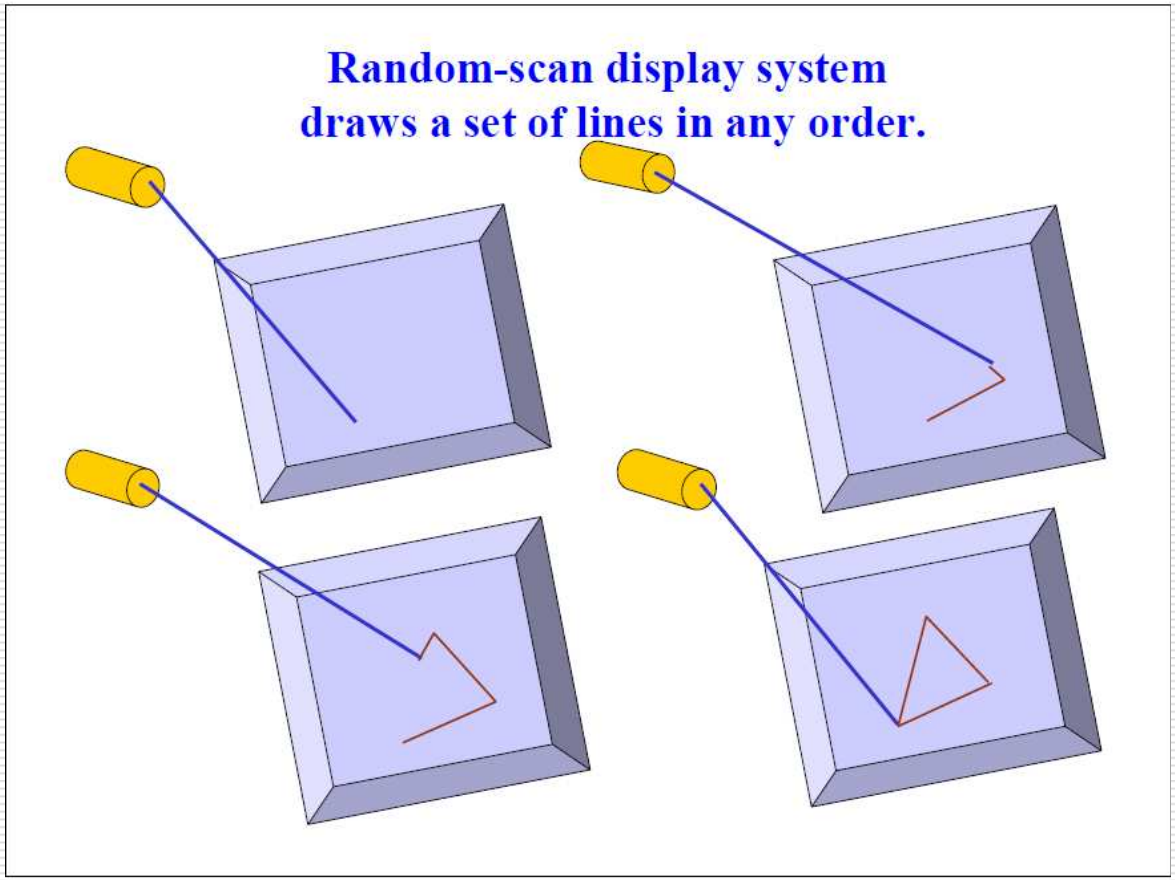
Architecture of a raster-graphics system with a display processor /Graphics Controller

- Additional operations of Display processor:
  - Generate line styles- Dotted, dashed or solid.
  - Display color areas.
  - Perform transformations, manipulations on displayed objects.
- Run length Encoding :To reduce memory requirements, frame buffer described as linked list and to store encoding intensity information.
  - Each scan line has set of integer pairs
    - Intensity value
    - Number of adjacent pixels on the scan line that have same intensity.
    - Useful for picture with long runs of single color .

Random Scan display system

- Random scan display unit directs the electron beam to the parts of the screen where the picture is to be drawn.
- Draws a picture one line at a time referred as vector displays.
- Refresh rate depends on number of lines to be displayed.
- Picture definition stored as line drawing commands in refresh display file/refresh buffer.
- To display a picture, system cycles through a set of commands in the display file drawing each component line in a turn.
- Draws lines of a picture in 30 – 60 times/sec.
- Random scan - Order of deflection is dictated by the arbitrary order of the display commands

Random scan Display system



Random scan Systems

- An application program input stored in the system memory along with graphics package.
- Graphics commands in the application program are translated into display file.
- Display file accessed by the display processor to refresh screen.
- Display processor cycles through each command in the display file program.
- Patterns drawn on the screen by directing the electron beam along the component lines of the picture.
- Lines are defined by their coordinate endpoints, these values are converted into deflection voltages.
- Scene is drawn one line at a time by positioning the beam to fill in the line between specified end points.

Raster Vs Random Displays

Raster Display	Random Display
Picture definition stored as discrete point.	Pixel definition stored as line drawing commands.
Display realistic shaded scenes.	Cannot display realistic scenes
Produces jagged lines plotted as discrete point sets.	Produces smooth lines.
CRTs, Printers, Home TV sets etc.	Pen plotters, Asteroids, CAD/CAM etc.
Decreasing memory costs have made raster systems popular.	Random-scan system's are generally costlier
Refresh time is not dependent on image complexity	Refresh time is dependent on image complexity.

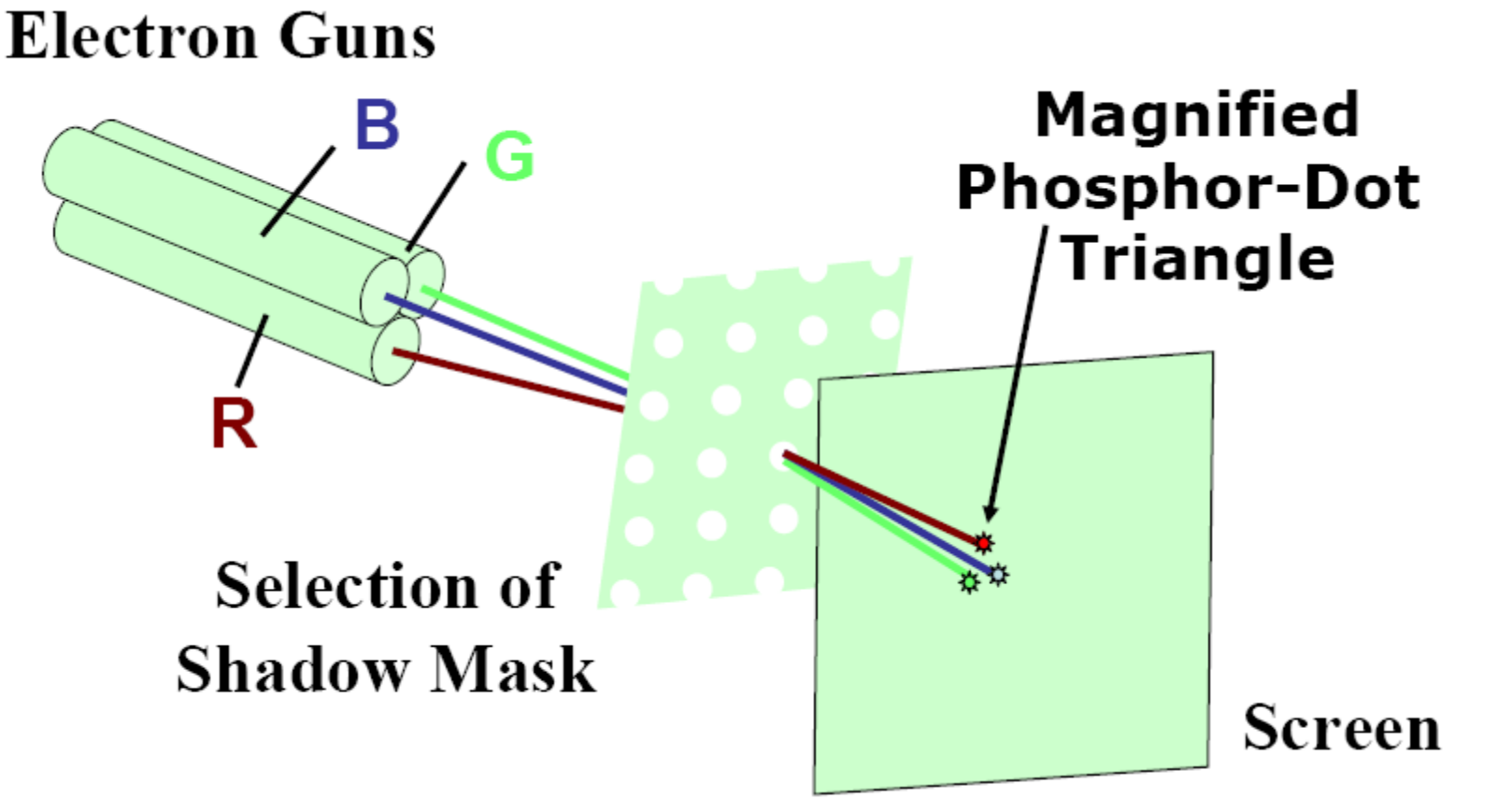
Color CRT Monitors

- Displays color pictures by using combination of phosphors that emit different colored light.
- By combining emitted light a range of colors generated.
- Basic Techniques:
  - Beam penetration
  - Shadow mask method.
- Beam penetration method:
  - Uses random-scan monitors.
  - Red and green phosphor coated inside the CRT screen.
  - Display depends upon how far beam penetrates the phosphor layers.
  - Fast electrons penetrates the red and excites the green
  - Intermediate speed beam produces combinations of red and green => orange,yellow
  - Produces only four colors , quality not good.

Color CRT Monitors
Shadow Methods

- Three electron guns, aligned with the triangular color-dot patterns on the screen.
- Directed to each dot triangle by a shadow mask.
- When beam pass through the hole in the shadow mask they activate a dot triangle (small color spot)
- The phosphor dots in the triangles are arranged so the beam can activate its corresponding color.
- Color variations obtained by turning off the corresponding gun.
- Commonly used in color CRTs.
- Several millions colors can be generated.

Color CRT Monitors
Shadow Methods



Direct View Storage Tubes (DVST)

- An alternative method for maintaining a screen image is to store the picture information inside the CRT instead of refreshing the screen.
- DVST stores the picture information
- Two electron guns are used in a DVST
  - Primary gun used to store the picture pattern
  - Flood gun maintains the picture display

Advantages

- No refreshing is needed, complex pictures can be displayed without any flicker.

Disadvantages

- Do not display color and selected parts of the picture cannot be erased.
- Modifying any part of the image requires redrawing the entire modified image
- Erasing and redrawing process take several seconds for a complex picture.
- No animation possible with DVST.

Flat Panel Devices

- Flat Panel Devices refers to a class of video devices that have reduced volume weight and power requirements.
  - Emissive Displays
  - Nonemissive Displays
- Emissive displays converts electrical energy into light.
  - Plasma Panels,LEDs
- Nonemissive uses optical effects to convert sunlight or light from other source into graphic patterns
  - Liquid crystal device.

Input Devices

- Trackball :2d positioning device mounted on keyboards.
- Spaceball: Provides six degree of freedom
  - Used for 3d positioning device in VR systems,modelling,animation CAD and other applications
- Data Glove: used to grasp virtual object.
  - Input from the glove used to position or manipulate objects in a virtual scene.
- Digitizers: used for drawing, painting for interactively selecting the coordinate positions on an object.
- Touch Panels, Voice Systems and Mouse

- Thank you