Computer Graphics
&
Multimedia Techniques

Unit-1

Basic of Computer Graphics

Computer Graphics

- Computer Graphics is an area of computer science and engineering which involves display, manipulation and storage of pictures and experimental data for proper visualization using a computer.
- Typical graphics system comprises of a host computer with support of fast processor, large memory, frame buffer and
  - Display devices(color monitors),
  - Input devices(mouse, keyboard, joystick, touch screen, trackball)
  - Output devices(LCD panels, laser printers, color printers. Plotters etc.)
  - Interfacing devices such as, video I/O, TV interface etc.

Applications of computer graphics

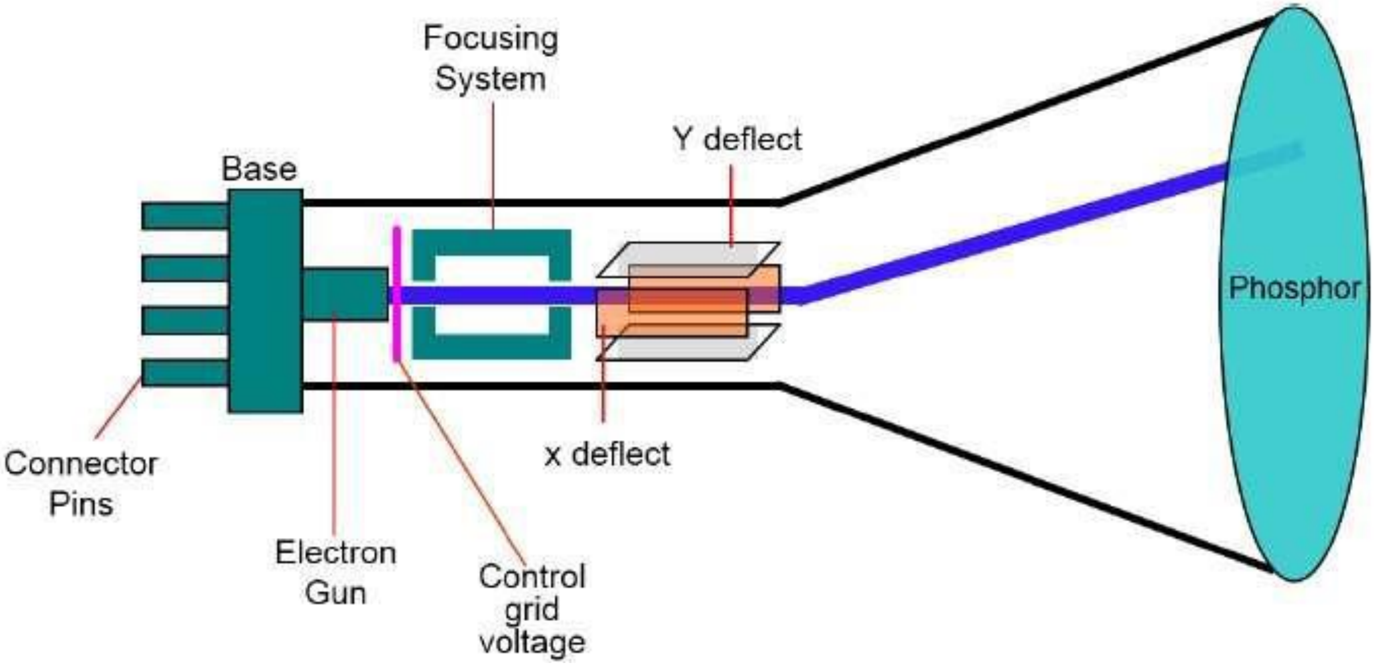
- Computer Aided Design
- Presentation Graphics
- Computer Art
- Entertainment
- Education and Training Visualization
- Image Processing
- Graphical User Interface

Display devices

- The most commonly used display device is the CRT Monitor
- Types of CRT Display Devices
  - DVST (Direct View Storage Tube)
  - Calligraphic or Random Scan display system
  - Refresh and Raster Scan display system

Working of Refresh CRT

- The primary output device in a graphical system is the monitor.
- The main element of a monitor is the Cathode Ray Tube (CRT), shown in the following illustration.

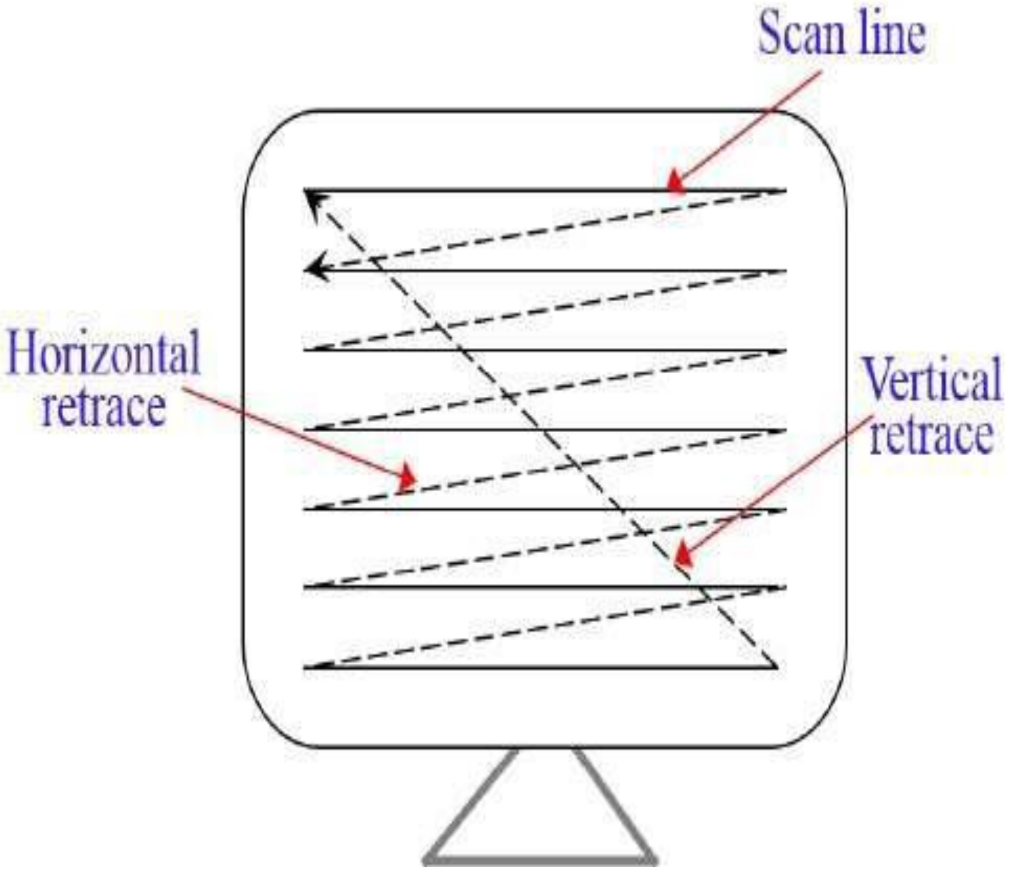


Working of Refresh CRT

- The operation of CRT is very simple –
  - The electron gun emits a beam of electrons (cathode rays).
  - The electron beam passes through focusing and deflection systems that direct it towards specified positions on the phosphor-coated screen.
  - When the beam hits the screen, the phosphor emits a small spot of light at each position contacted by the electron beam.
  - It redraws the picture by directing the electron beam back over the same screen points quickly.
- There are two ways (**Random scan** and **Raster scan**) by which we can display an object on the screen.

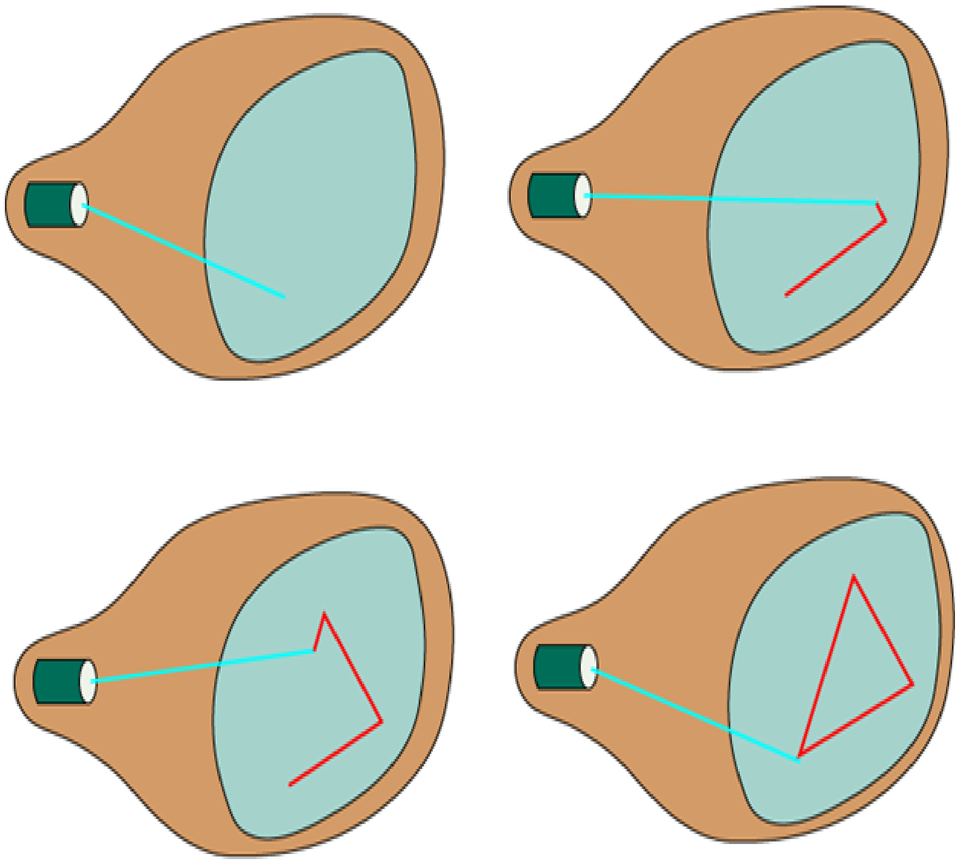
Raster scan displays:

- In a 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 row, the beam intensity is turned on and off to create a pattern of illuminated spots. Picture definition is stored in memory area called the Refresh Buffer or Frame Buffer. This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and “painted” on the screen one row (scan line) at a time as shown in the following illustration. Each screen point is referred to as a pixel (picture element) or pel. 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.



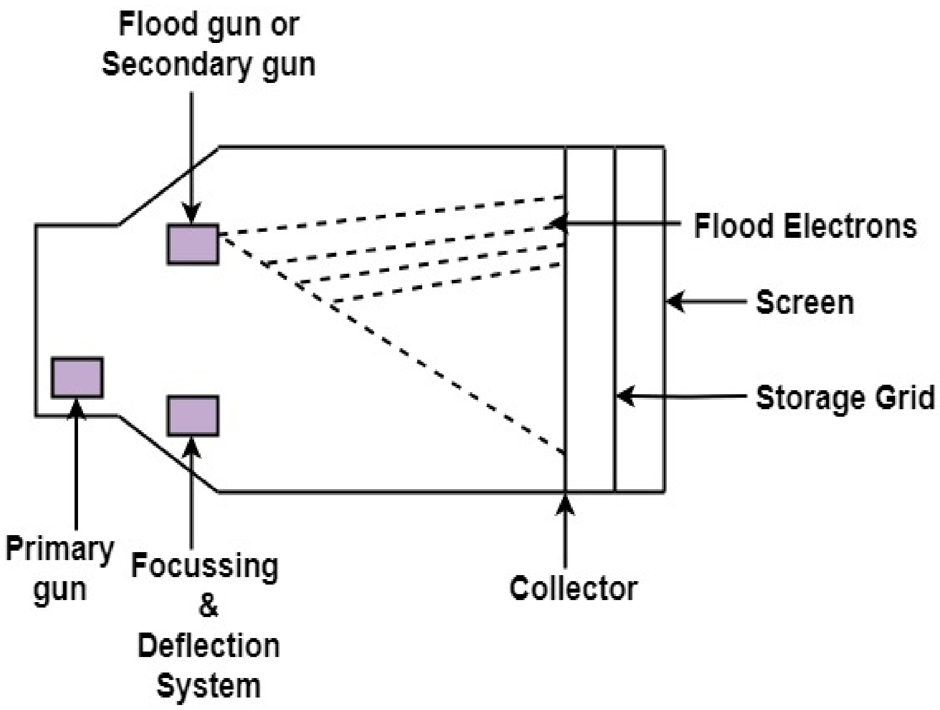
Random Scan Display:

- Random Scan System uses an electron beam which operates like a pencil to create a line image on the CRT screen. The picture is constructed out of a sequence of straight-line segments. Each line segment is drawn on the screen by directing the beam to move from one point on the screen to the next, where its x & y coordinates define each point. After drawing the picture. The system cycles back to the first line and design all the lines of the image 30 to 60 time each second. The process is shown in figure. Random-scan monitors are also known as vector displays or stroke-writing displays or calligraphic displays



Storage tube displays (DVST):

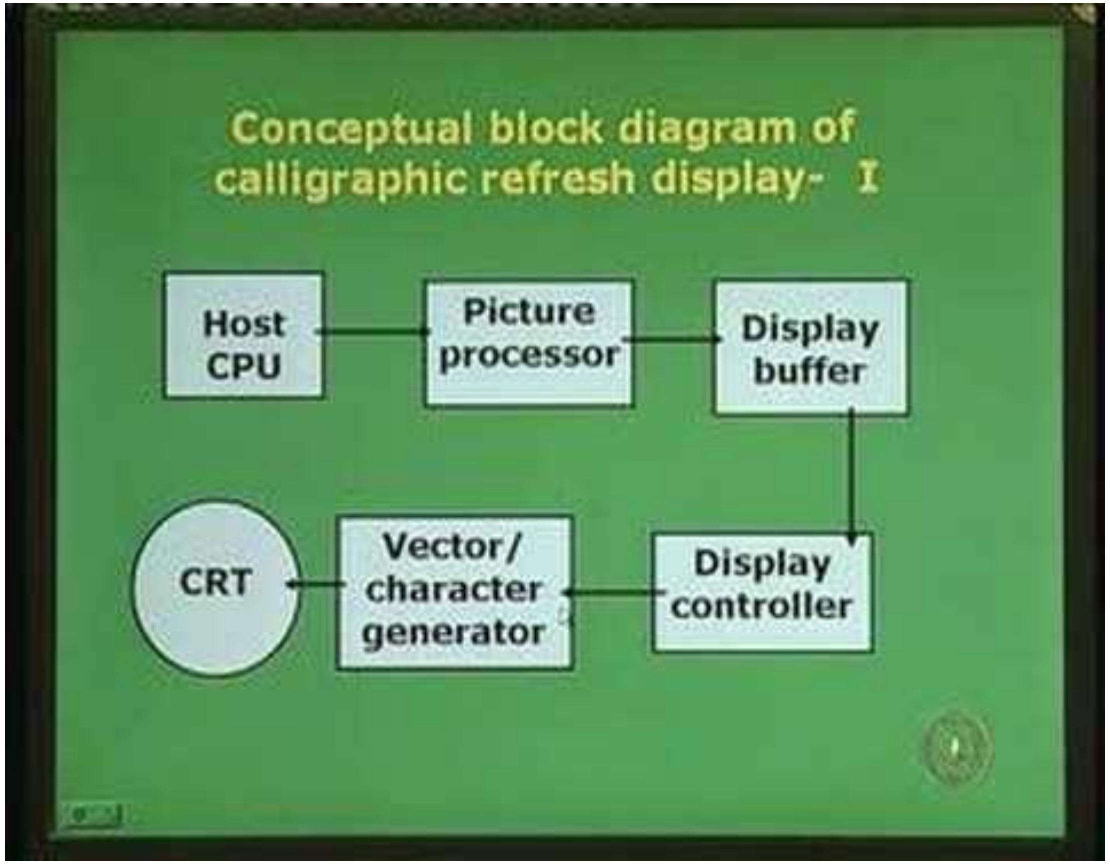
- DVST (Direct View Storage Tube) terminals also use the random scan approach to generate the image on the CRT screen. The term "storage tube" refers to the ability of the screen to retain the image which has been projected against it, thus avoiding the need to rewrite the image constantly.
- Function of guns: Two guns are used in DVST
- Primary guns: It is used to store the picture pattern.
- Flood gun or Secondary gun: It is used to maintain picture display



Direct View Storage Tube

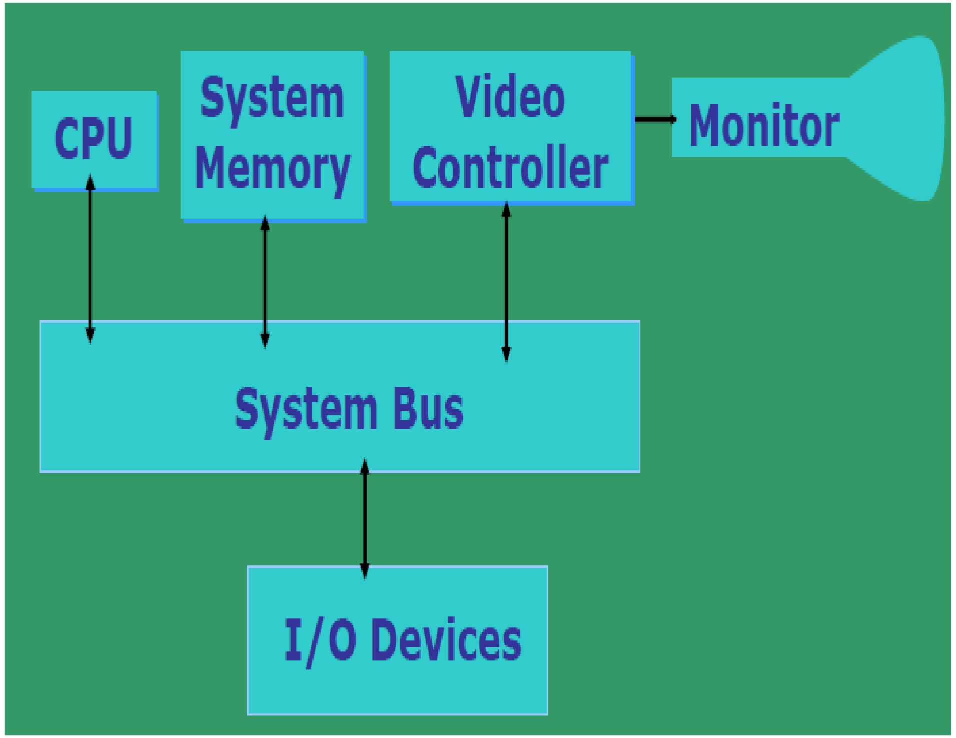
Calligraphic or Random scan display system

- Also called Vector, Stroke, Line Drawing displays
- Refresh Buffer – memory space allocated to store the display list or Display program for the display processor to draw the picture
- The display processor interprets the commands in the refresh buffer for plotting
- The display processor must cycle through the display list to refresh the phosphor
- The display program has commands for point-, line-, and character-plotting



Refresh and Raster scan display system

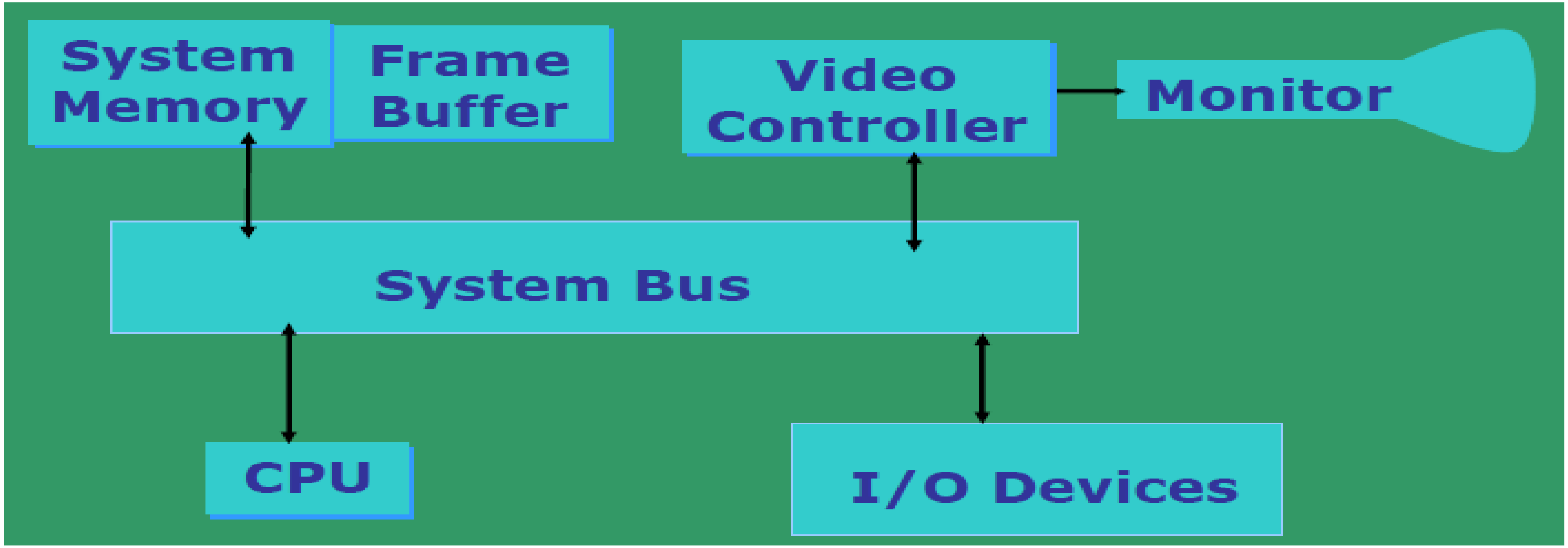
- Used in television screens
- Unlike DVST and random-scan which were line-drawing devices, refresh CRT is a Point-Plotting device
- Raster displays store the display primitives (lines, characters, shaded and patterned areas) in a refresh buffer
- Refresh Buffer (frame buffer) stores the drawing primitives in terms of points and pixels components



Architecture of a simple raster graphics system

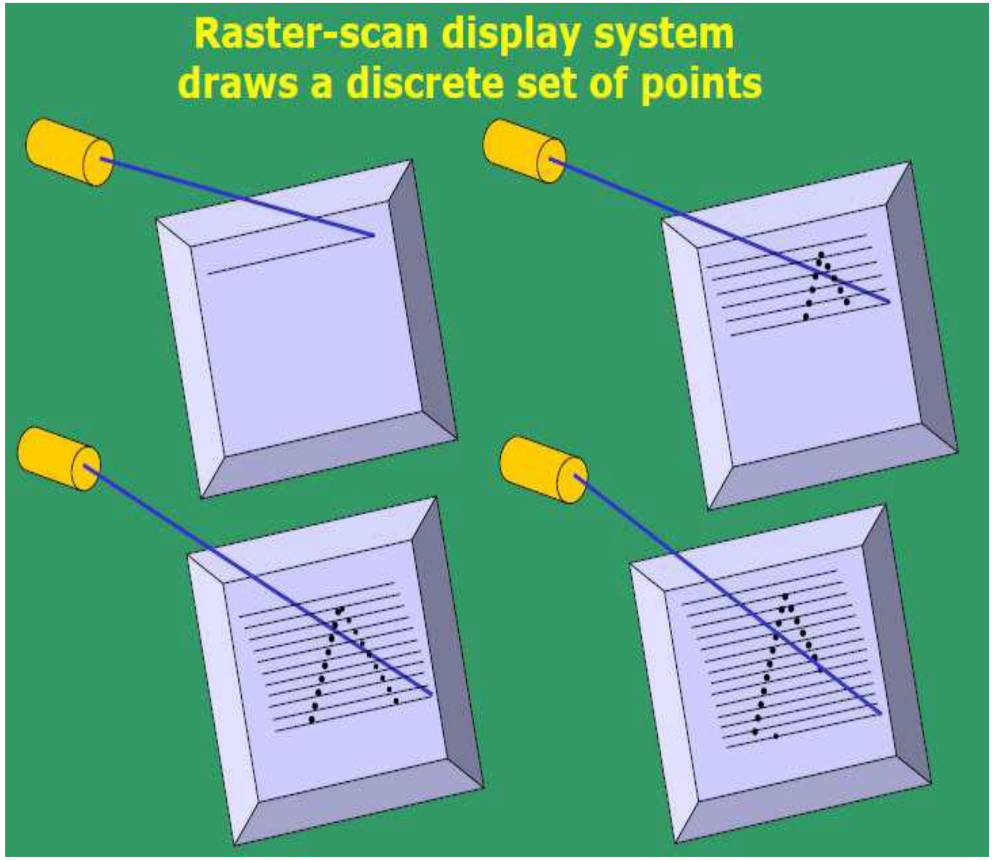
Refresh and Raster scan display system

- Architecture of a Raster System with a fixed portion of the system memory reserved for the frame buffer



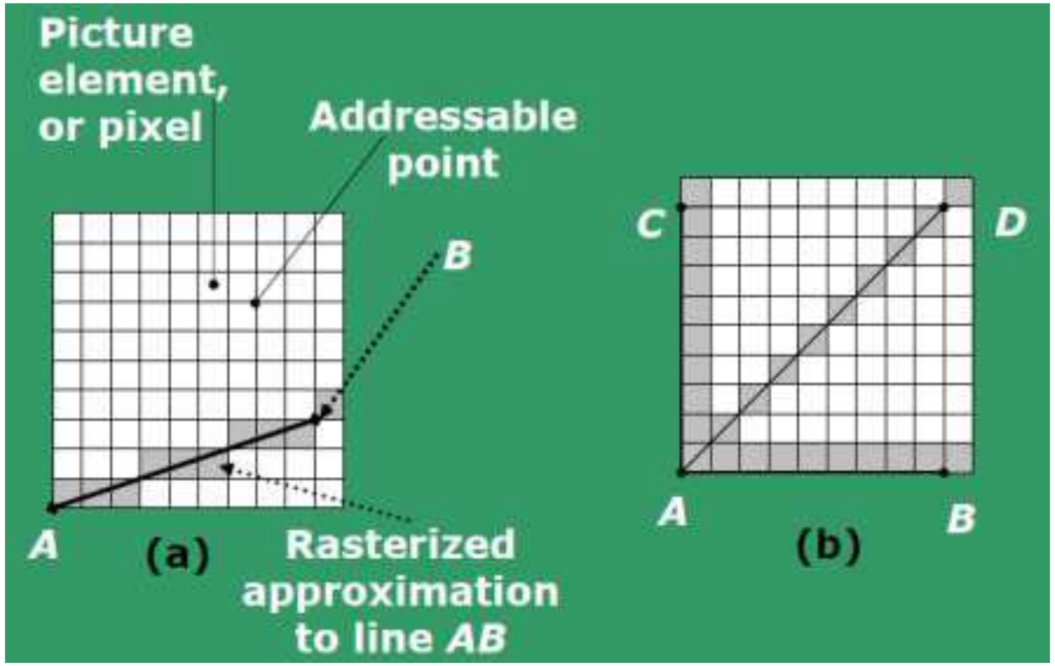
Refresh and Raster scan display system

- Entire Screen is a matrix of pixels
- Each pixel brightness can be controlled
- Refresh buffer can be visualized as a set of horizontal raster lines or a row of individual pixels
- Each point is an addressable point in screen and memory
- Line cannot be drawn directly from one point to another
- This is causes the effect of 'Aliasing', 'Jaggies', or 'Staircase' Effect
- Refresh/Frame Buffer is also called Bit-Plane



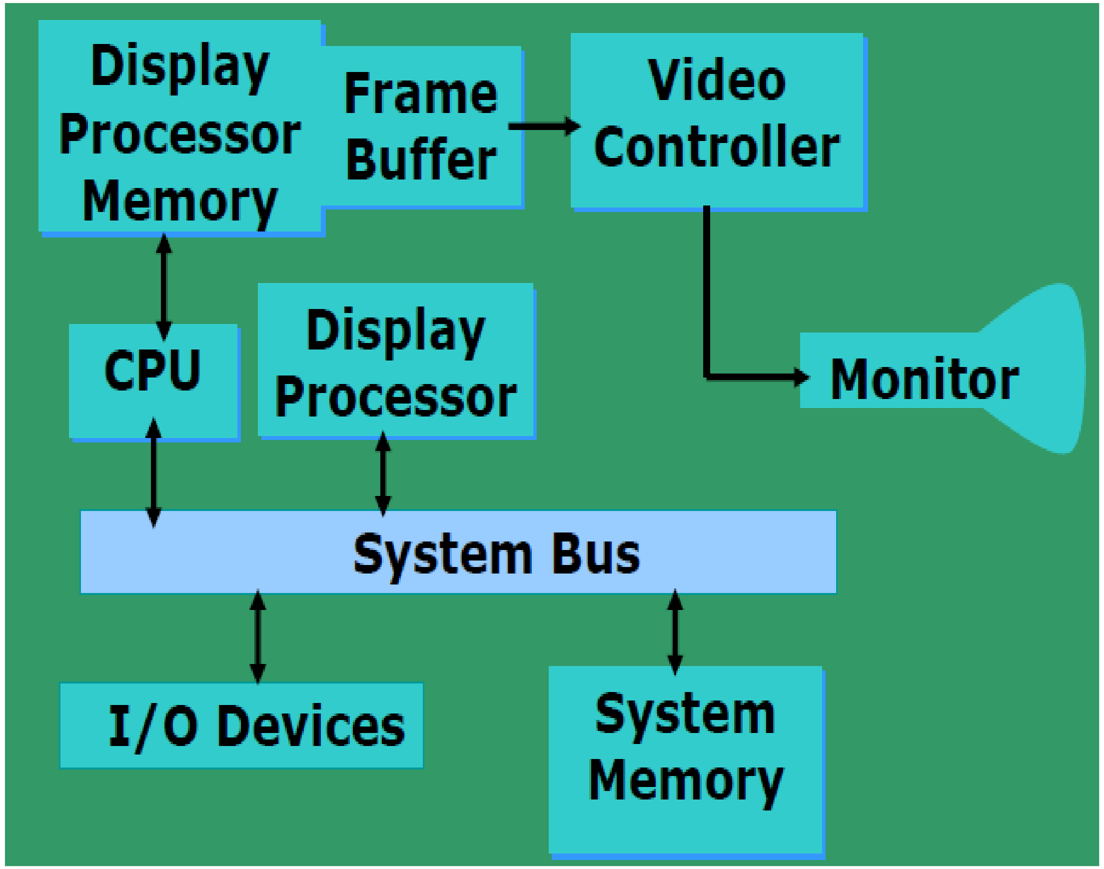
Refresh and Raster scan display system

- Raster is stored as a matrix of pixels representing the entire screen area
- Entire image is scanned out sequentially by the video controller (one raster line at a time)
- The raster lines are scanned from top to bottom and then back to the top
- The intensity of the beam decides the brightness of the pixel
- At least one memory bit for each pixel (called bit-plane)

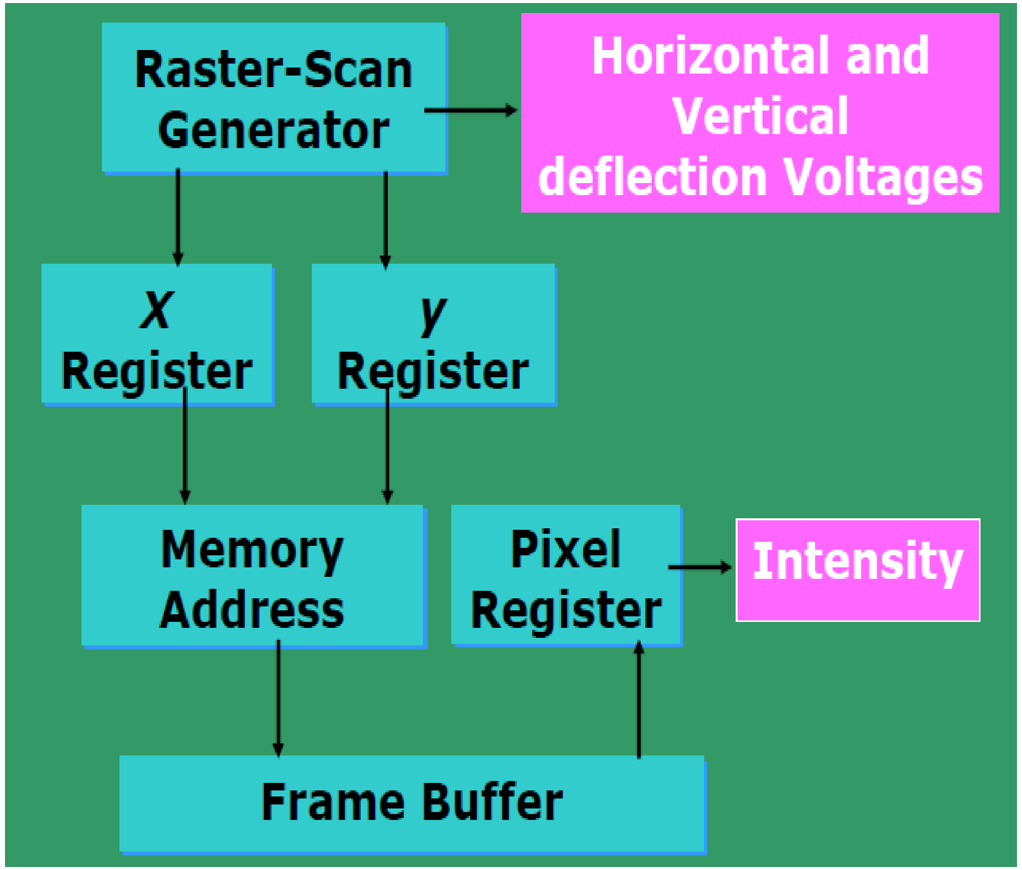


- Rasterization: (a) General Line; (b) Special Cases

Refresh and Raster scan display system

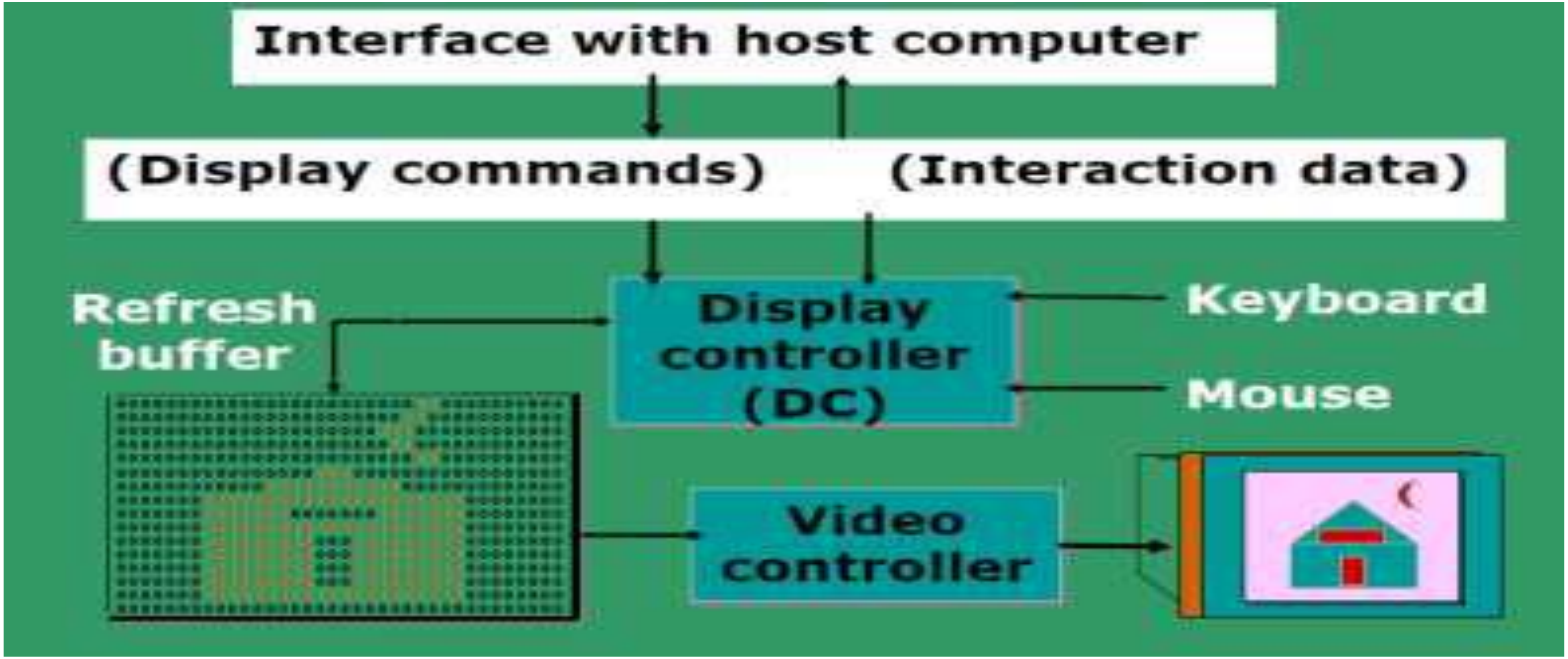


Architecture of a raster-graphics system with a display processor



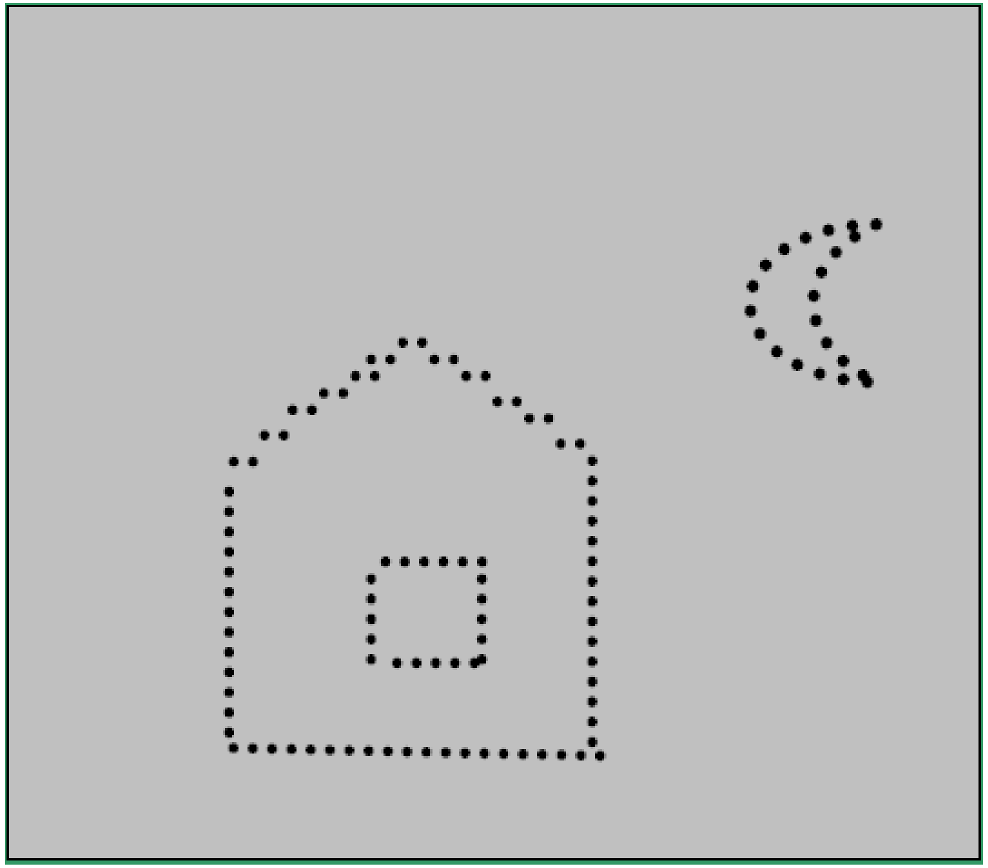
Basic video-controller refreshes operations

Refresh and Raster scan display system

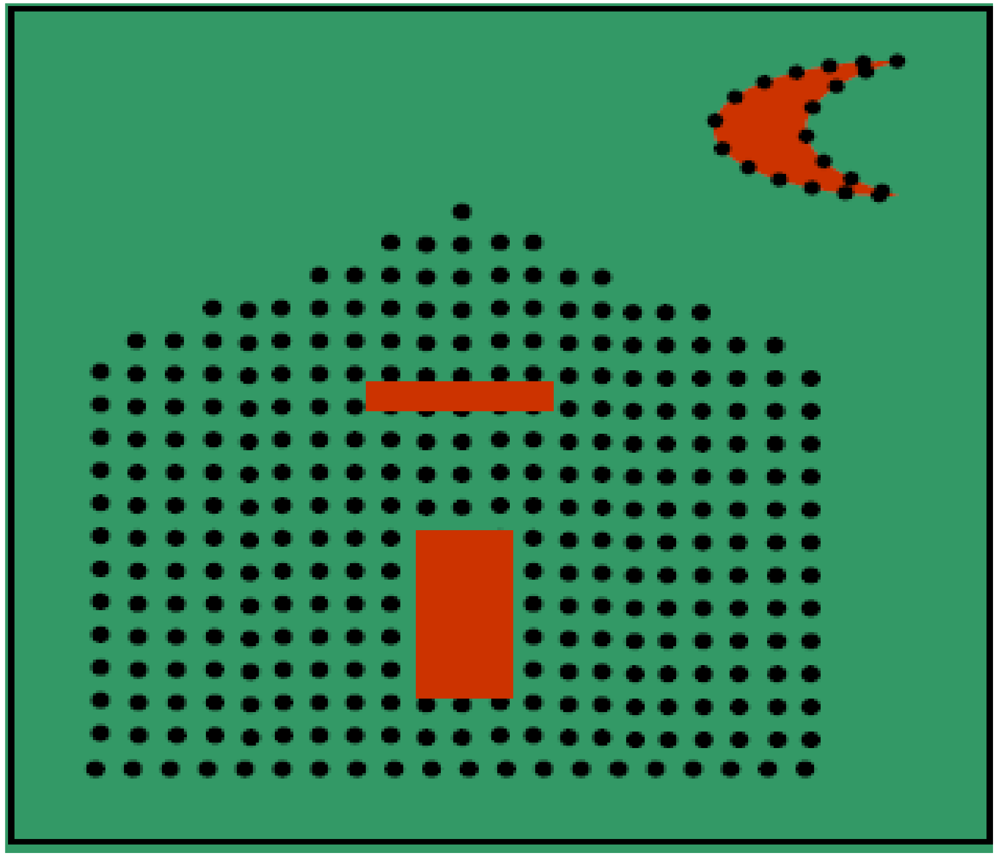


Architecture of a raster display

Refresh and Raster scan display system



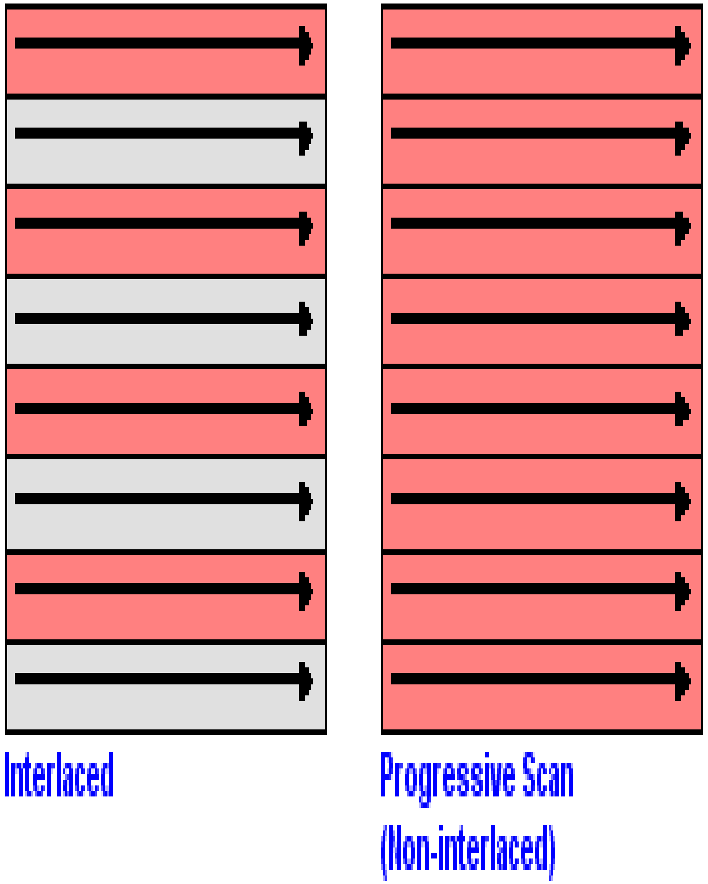
Raster scan with outline primitives



Raster scan with filled primitives

Refresh and Raster scan display system

- **Refreshing:** Electron guns in the cathode ray tube (CRT) constantly sweep across the screen to redrawing the display, this process is called refreshing.
- **Flickering:** A flicker is the appearance of flashing or unsteadiness in an image on a display screen. This issue can occur when the video refresh rate is too low, other video related issues, and in some cases hardware issues with the monitor. Commonly, when this issue occurs, users will experience more eyestrain.
- **Interlacing:** interlacing is a process of how the picture is created. With an interlaced display the picture is created by scanning every other line, and on the next scan, scanning every opposite line. Interlacing allows for a faster refresh rate by having less information during each scan at a lower cost. Unfortunately, this may cause flickering or noticeable line movements in some situations.



Refresh and Raster scan display system

- **Resolution:** The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution.
- **Persistence:** For the phosphors coated on the screen, persistence represents the duration they continue to emit light after the CRT 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 without flicker.
- **Aspect ratio:** This number gives the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen. An aspect ratio of 3 / 4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.

HD Resolutions

Name	Resolution	Aspect ratio
nHD	640x360	16:9
qHD	960x540	16:9
HD	1280x720	16:9
HD+	1600x900	16:9
FHD	1920x1080	16:9
QHD	2560x1440	16:9
4K UHD	3840x2160	16:9
8K UHD	7680x4320	16:9

Table High Definition

Refresh and Raster scan display system

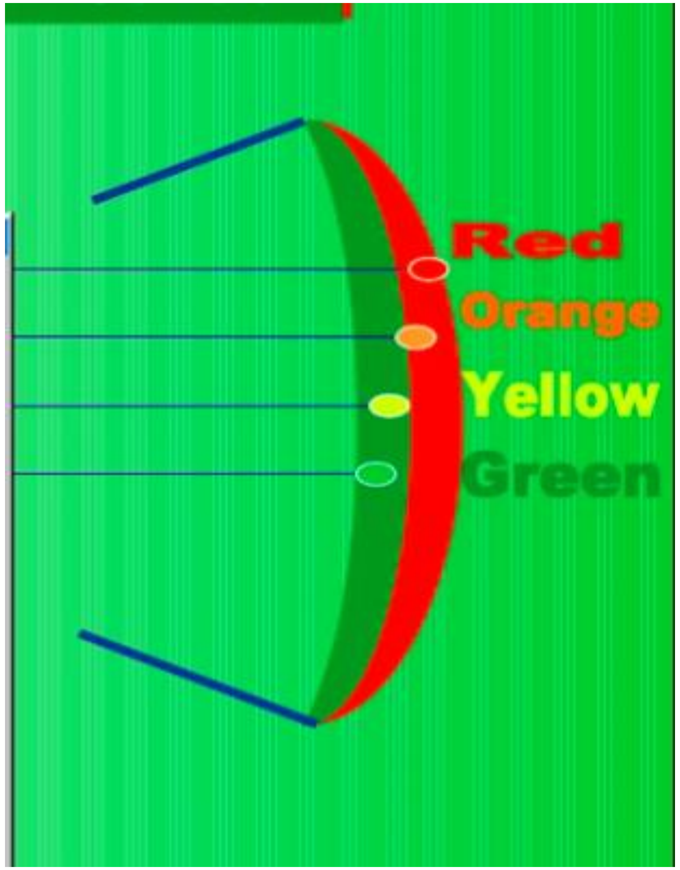
- A typical example:
  - If one uses a 512x512 element raster display, then 218 bits are necessary in a single bit plane. Memory size required: 32 KB
  - A DAC (digital-to-analog converter) is used to convert the bit value (0, 1) to analog signals for refreshing the screen
- Memory size required for N-bit plane gray level frame buffers:
- **N Size in KB**

N	Size in KB
3	96
8	256
24	768

- Refresh rate to avoid flickering – 60 Hz

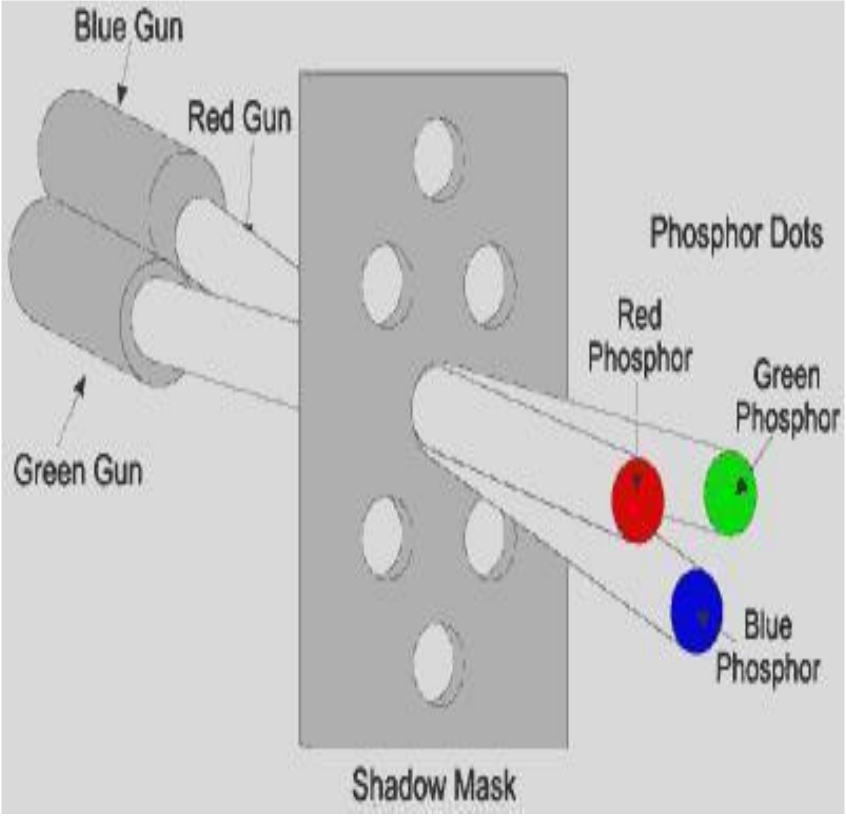
Color monitors:

- Two methods employed in CRT for color
  - **Beam Penetration**
  - **Shadow-mask**
- **Beam Penetration:**
  - Random scan monitors use the beam penetration method for displaying color picture. In this the inside of CRT screen is coated with two layers of phosphor namely red and green. A beam of slow electrons excites only the outer red layer, while a beam of fast electrons penetrates red layer and excites the inner green layer as shown in figure. At intermediate beam speeds, combination of red and green light are emitted to show two additional colors – orange and yellow.



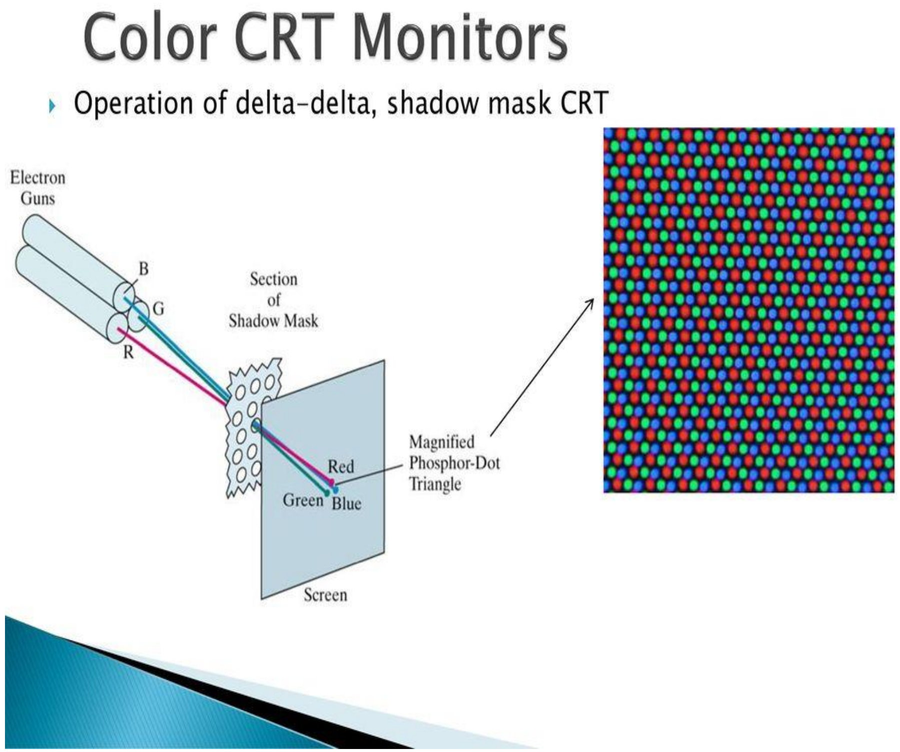
Color monitors:

- **Shadow-mask**
  - Raster scan systems use shadow mask methods to produce a much more range of colors than beam penetration method. In this, CRT has three phosphor color dots. One phosphor dot emits a red light, second emits a green light and third emits a blue light. This type of CRT has three electron guns and a shadow mas" grid.
  - Two methods of shadow-mask that are **inline** and **delta-delta**



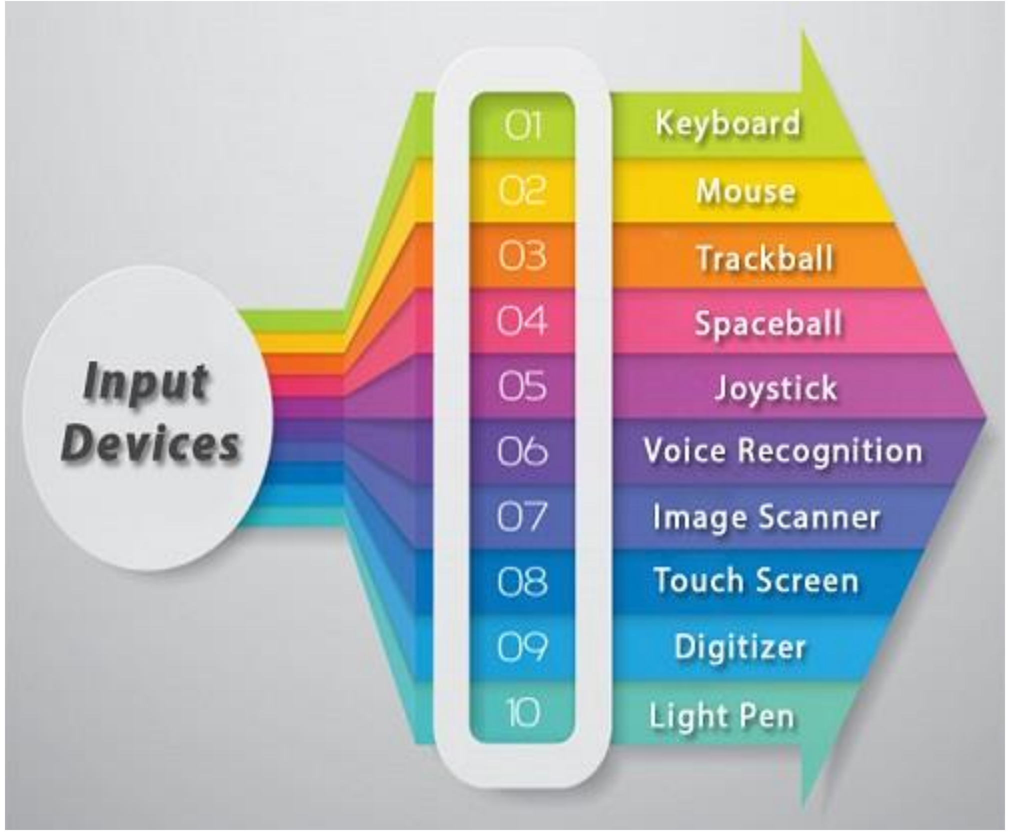
Color monitors:

- Inline
  - 3 electron guns is an Inline arrangement in which the 3 electron guns and the corresponding red-green-blue color dots on the screen, are aligned along one scan line rather of in a triangular pattern
- Delta-Delta
  - 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" as shown. Each pixel point on the screen is also made up of 3 types of phosphors to produce red, blue and green colors. Just before the phosphor screen is a metal screen, called a "shadow mask".



Input Devices:

- The Input Devices are the hardware that is used to transfer transfers input to the computer. The data can be in the form of text, graphics, sound, and text. Output device display data from the memory of the computer. Output can be text, numeric data, line, polygon, and other objects.
- These Devices include:
    - Keyboard
    - Mouse
    - Trackball
    - Spaceball
    - Joystick
    - Light Pen
    - Digitizer
    - Touch Panels
    - Voice Recognition
    - Image Scanner



Overview of programmer’s model of interactive graphics:

- PHIGS (Programmer's Hierarchical Interactive Graphics Standard) is an application programming interface (API) standard for rendering 3D computer graphics, considered to be the 3D graphics standard for the 1980s through the early 1990s. Subsequently, a combination of features and power led to the rise of OpenGL, which became the most popular professional 3D API of the mid to late 1990s.
- OpenGL, unlike PHIGS, was an immediate-mode rendering system with no "state"; once an object is sent to a view to be rendered it essentially disappears. Changes to the model had to be re-sent into the system and re-rendered, a dramatically different programming mind-set. For simple projects, PHIGS was considerably easier to use and work with. However, OpenGL's "low-level" API allowed the programmer to make dramatic improvements in rendering performance by first examining the data on the CPU-side before trying to send it over the bus to the graphics engine.

Fundamental problems in geometry:

- The core problems in computational geometry may be classified in different ways, according to various criteria. The following general classes may be distinguished.
- **Static problems :**
- In the problems of this category, some input is given and the corresponding output needs to be constructed or found. Some fundamental problems of this type are:
- Convex hull: Given a set of points, find the smallest convex polyhedron/polygon containing all the points.
- Line segment intersection: Find the intersections between a given set of line segments.
- Voronoi diagram: Given a set of points, partition the space according to which points are closest to the given points.
- Linear programming
- Closest pair of points: Given a set of points, find the two with the smallest distance from each other.
- Largest empty circle: Given a set of points, find a largest circle with its center inside of their convex hull and enclosing none of them.
- Euclidean shortest path: Connect two points in a Euclidean space (with polyhedral obstacles) by a shortest path.
- Polygon triangulation: Given a polygon, partition its interior into triangles
- Mesh generation
- Boolean operations on polygons
- The computational complexity for this class of problems is estimated by the time and space (computer memory) required to solve a given problem instance.

Fundamental problems in geometry:

- **Geometric query problems**
- In geometric query problems, commonly known as geometric search problems, the input consists of two parts: the search space part and the query part, which varies over the problem instances. The search space typically needs to be preprocessed, in a way that multiple queries can be answered efficiently.
- Some fundamental geometric query problems are:
- Range searching: Preprocess a set of points, in order to efficiently count the number of points inside a query region.
- Point location: Given a partitioning of the space into cells, produce a data structure that efficiently tells in which cell a query point is located.
- Nearest neighbor: Preprocess a set of points, in order to efficiently find which point is closest to a query point.
- Ray tracing: Given a set of objects in space, produce a data structure that efficiently tells which object a query ray intersects first.
- If the search space is fixed, the computational complexity for this class of problems is usually estimated by:
- the time and space required to construct the data structure to be searched in the time (and sometimes an extra space) to answer queries.
- For the case when the search space is allowed to vary, see "Dynamic problems".

Fundamental problems in geometry:

- **Dynamic problems**
- Yet another major class is the dynamic problems, in which the goal is to find an efficient algorithm for finding a solution repeatedly after each incremental modification of the input data (addition or deletion input geometric elements). Algorithms for problems of this type typically involve dynamic data structures. Any of the computational geometric problems may be converted into a dynamic one, at the cost of increased processing time. For example, the range searching problem may be converted into the dynamic range searching problem by providing for addition and/or deletion of the points. The dynamic convex hull problem is to keep track of the convex hull, e.g., for the dynamically changing set of points, i.e., while the input points are inserted or deleted.
- The computational complexity for this class of problems is estimated by:
- the time and space required to construct the data structure to be searched in the time and space to modify the searched data structure after an incremental change in the search space the time (and sometimes an extra space) to answer a query.

Fundamental problems in geometry:

- **Variations**
- Some problems may be treated as belonging to either of the categories, depending on the context. For example, consider the following problem.
- Point in polygon: Decide whether a point is inside or outside a given polygon.
- In many applications this problem is treated as a single-shot one, i.e., belonging to the first class. For example, in many applications of computer graphics a common problem is to find which area on the screen is clicked by a pointer. However, in some applications, the polygon in question is invariant, while the point represents a query. For example, the input polygon may represent a border of a country and a point is a position of an aircraft, and the problem is to determine whether the aircraft violated the border. Finally, in the previously mentioned example of computer graphics, in CAD applications the changing input data are often stored in dynamic data structures, which may be exploited to speed-up the point-in-polygon queries.
- In some contexts of query problems there are reasonable expectations on the sequence of the queries, which may be exploited either for efficient data structures or for tighter computational complexity estimates. For example, in some cases it is important to know the worst case for the total time for the whole sequence of N queries, rather than for a single query. See also "amortized analysis".


Thanks!