

Course Title: Computer Graphics and Multimedia(CGM)

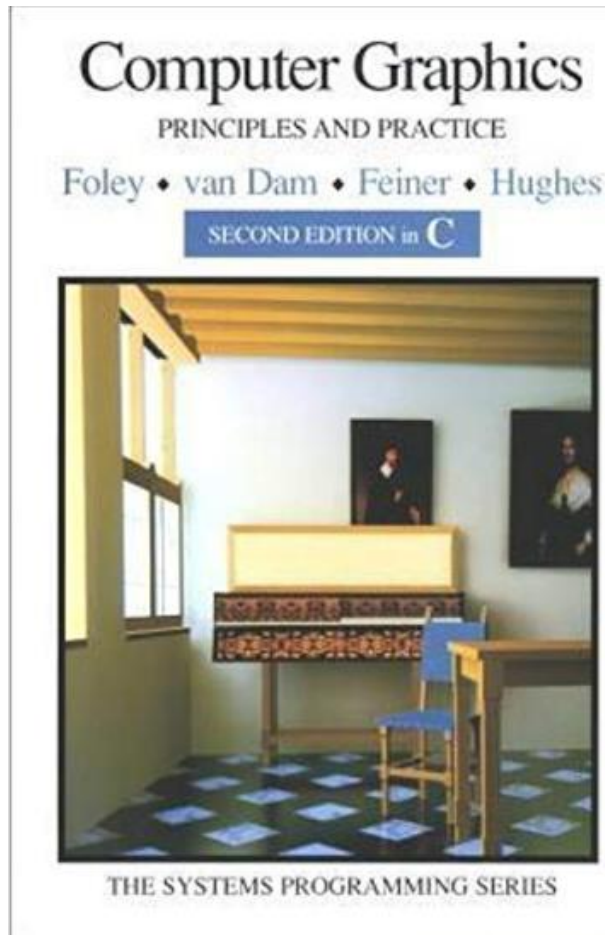
Course Instructor: Dr. Prerana Mukherjee (PhD, IIT Delhi)

Course Webpage: TBD

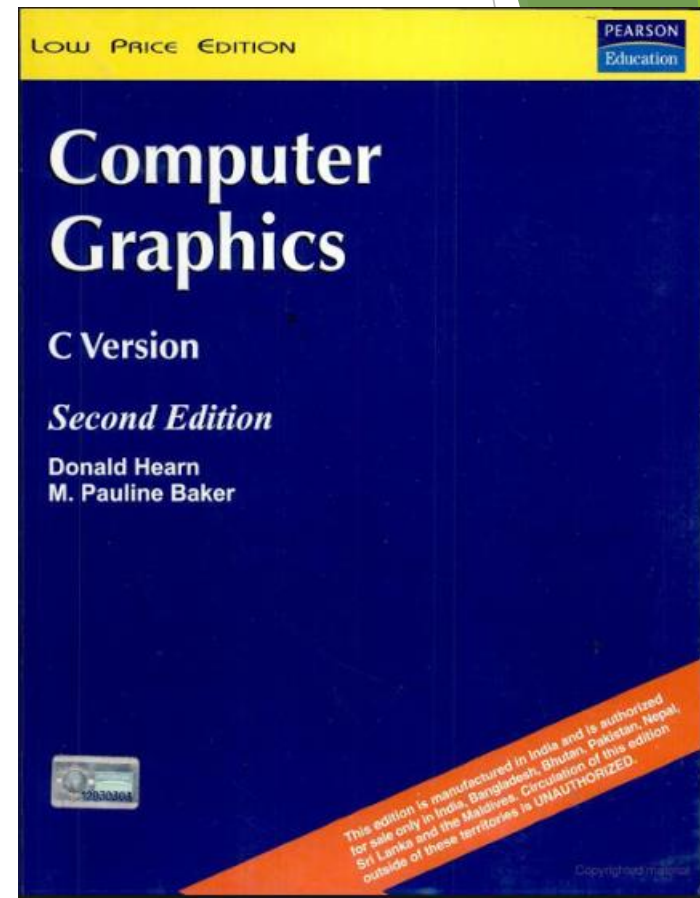


Teaching Assistants (TAs):

Textbooks



Computer Graphics (2nd Edition) by Foley



Computer Graphics (2nd Edition) by Hearn and Baker

CHAPTER 2

Display Devices-CRT

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**

Types of CRT display devices

- **DVST (Direct View Storage Tube)**
- **Calligraphic or Random Scan display system**
- **Refresh and raster scan display system**

DVST - Direct View Storage Tube

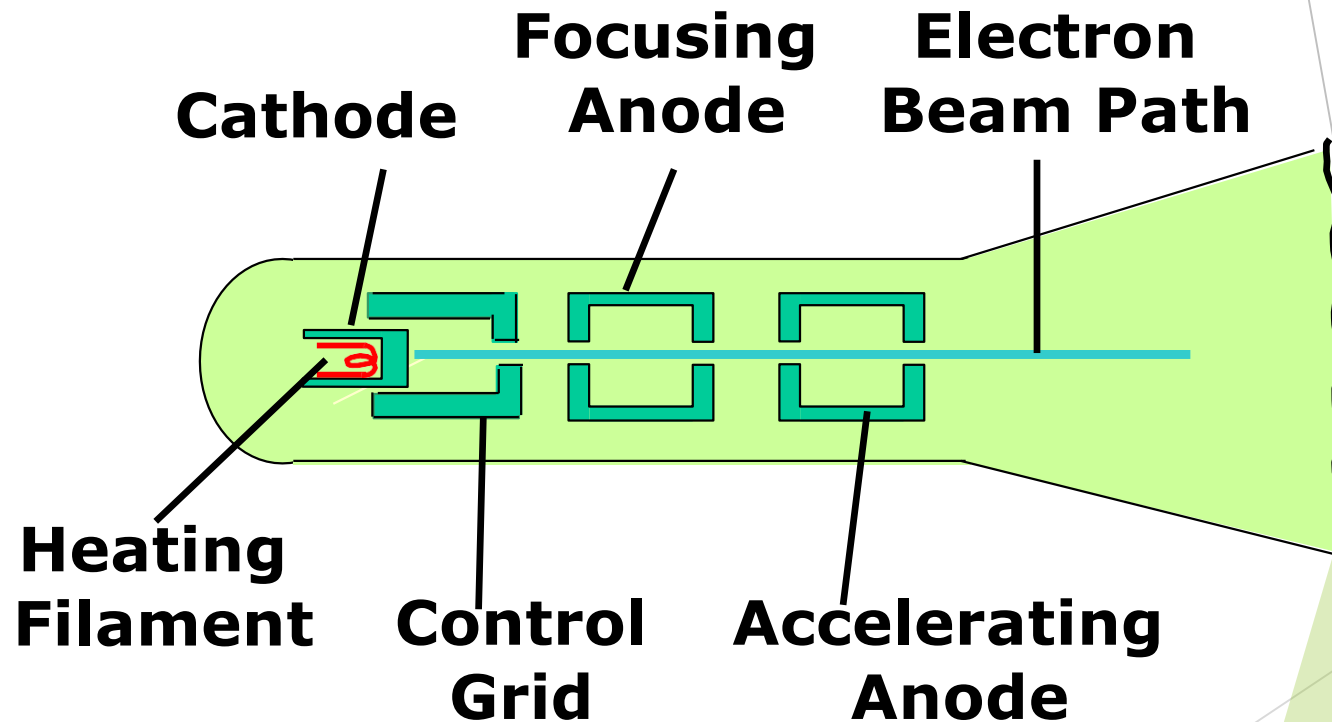
- **Storage Tube – it is a CRT with a long persistence phosphor**
- **Provides flicker-free display**
- **No refreshing necessary**

DVST - Direct View Storage

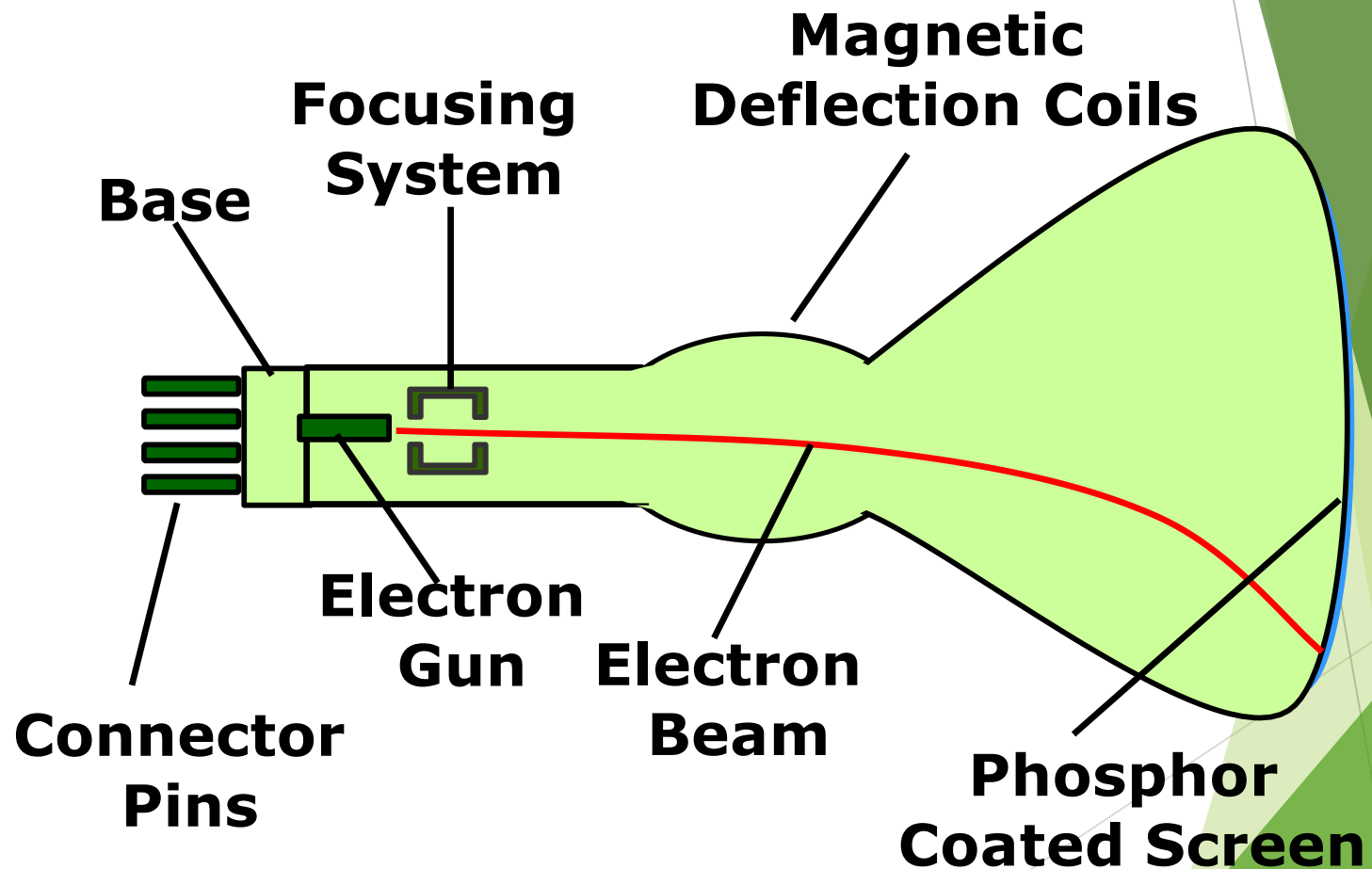
Tube

- **A slow moving electron beam draws a line on the screen**
- **Screen has a storage mesh in which the phosphor is embedded**
- **Image is stored as a distribution of charges on the inside surface of the screen**
- **Limited interactive support**

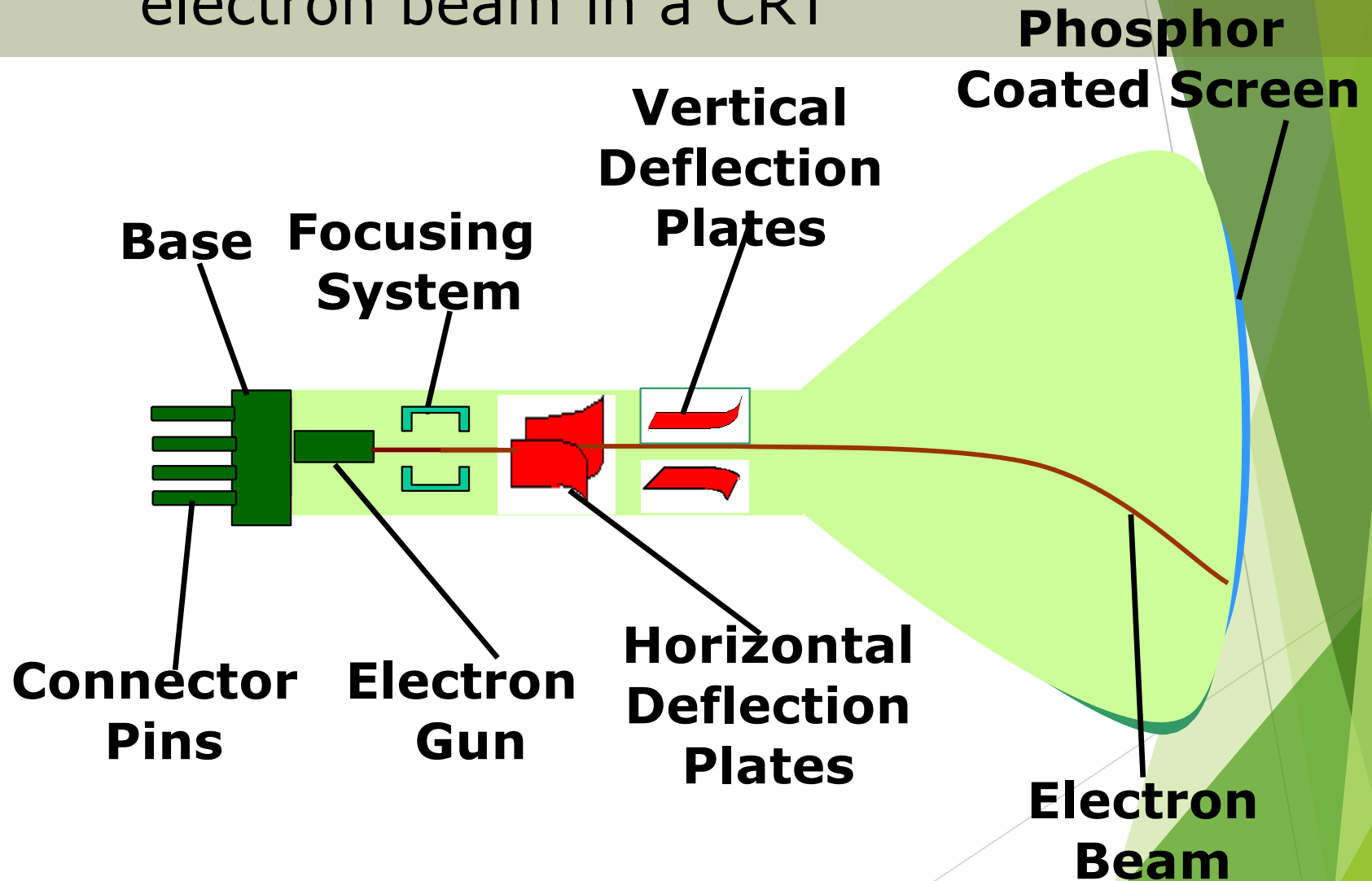
Operation of an electron gun with an accelerating anode



Basic design of a Magnetic deflection CRT



Electrostatic deflection of the electron beam in a CRT



DVST - Direct View Storage Tube (contd.)

Drawbacks

- **Modifying any part of the image requires redrawing the entire modified image**
- **Change in the image requires to generate a new charge distribution in the DVST**
- **Slow process of drawing – typically a few seconds are necessary for a complex picture**
- **Erasing takes about 0.5 seconds. All lines and characters must be erased**
- **No animation possible with DVST**

Calligraphic or Random Scan display system

- **Also called Vector, Stroke, Line drawing displays**
- **Characters are also made of sequences of strokes (or short lines)**
- **Vectored – electron beam is deflected from end-point to end-point**
- **Random scan - Order of deflection is dictated by the arbitrary order of the display commands**
- **Phosphor has short persistence – decays in 10-100 μs**

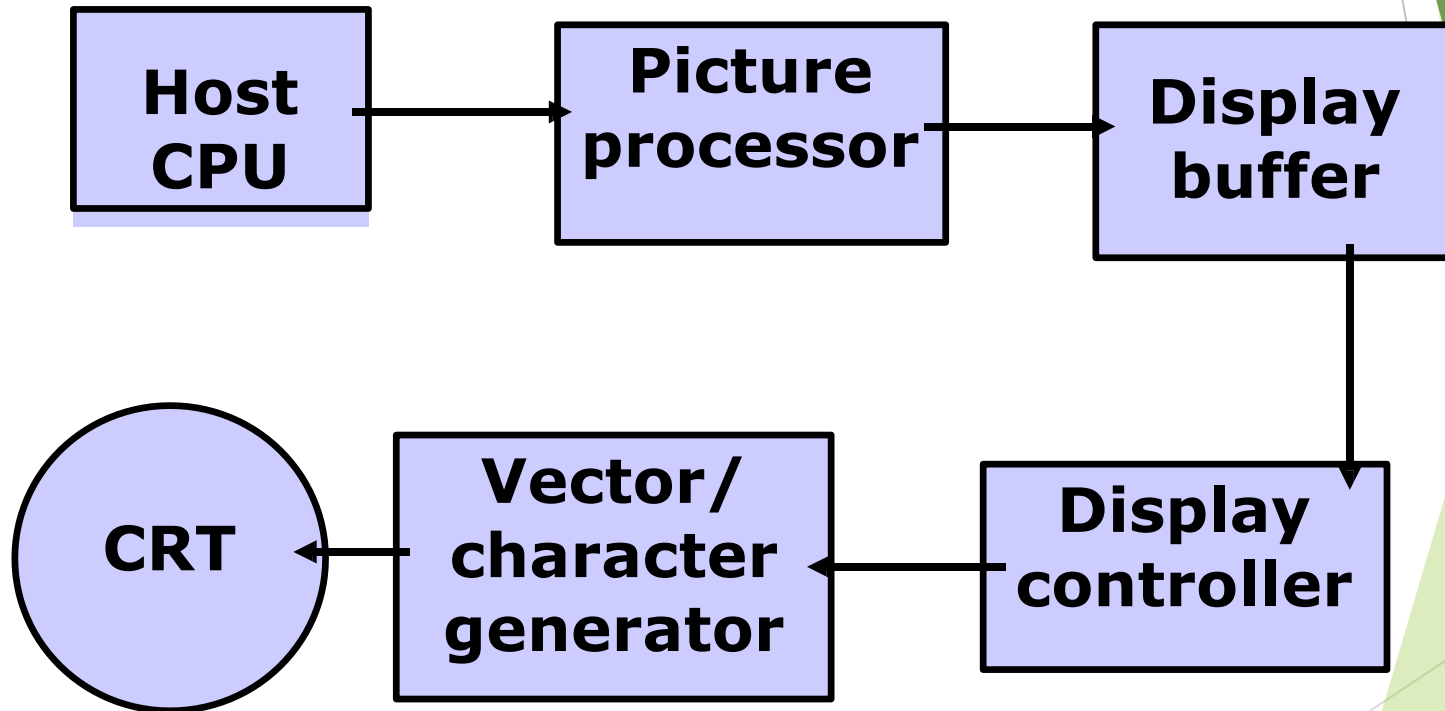
Calligraphic or Random Scan display system (contd.)

- **The display must be refreshed at regular intervals – minimum of 30 Hz (fps) for flicker-free display**

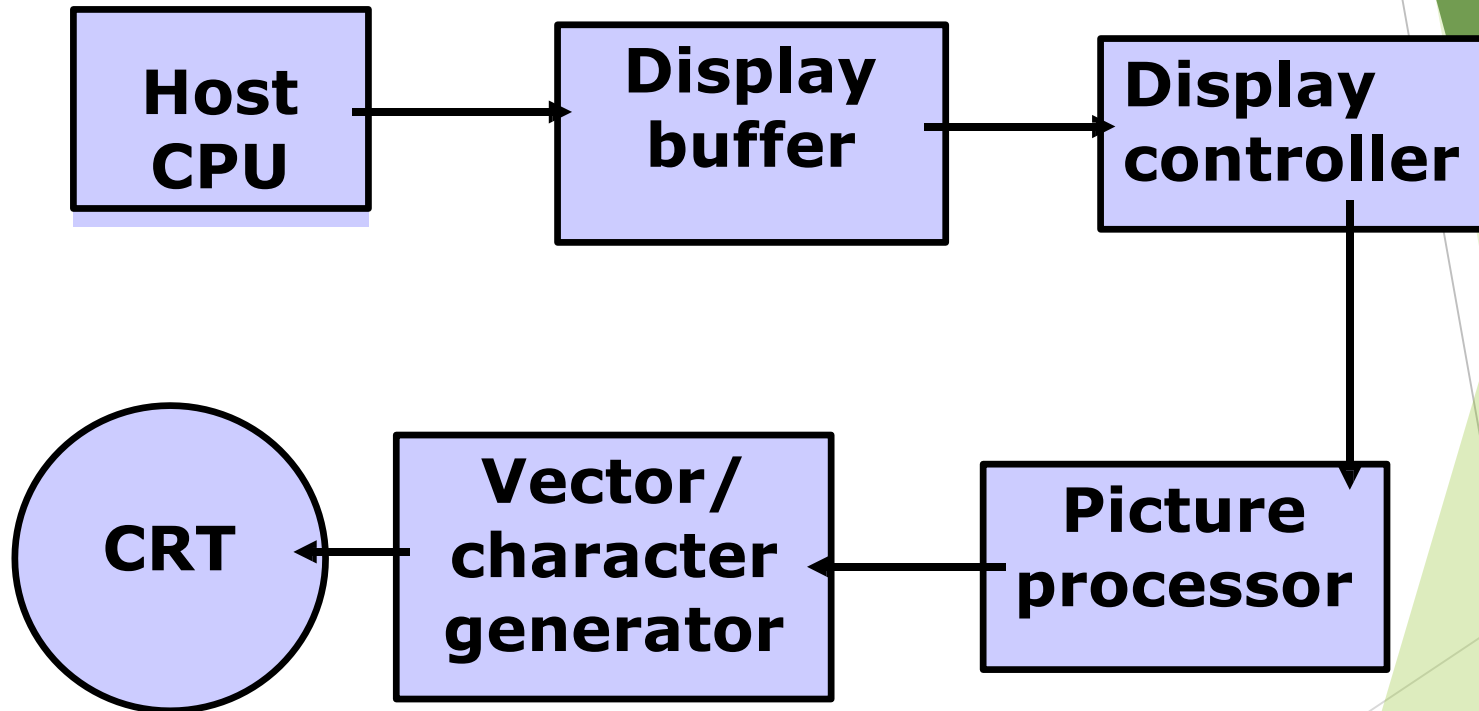
Refresh Buffer – memory space allocated to store the display list or display program for the display processor to draw the picture

- **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**

Conceptual block diagram of calligraphic refresh display - I



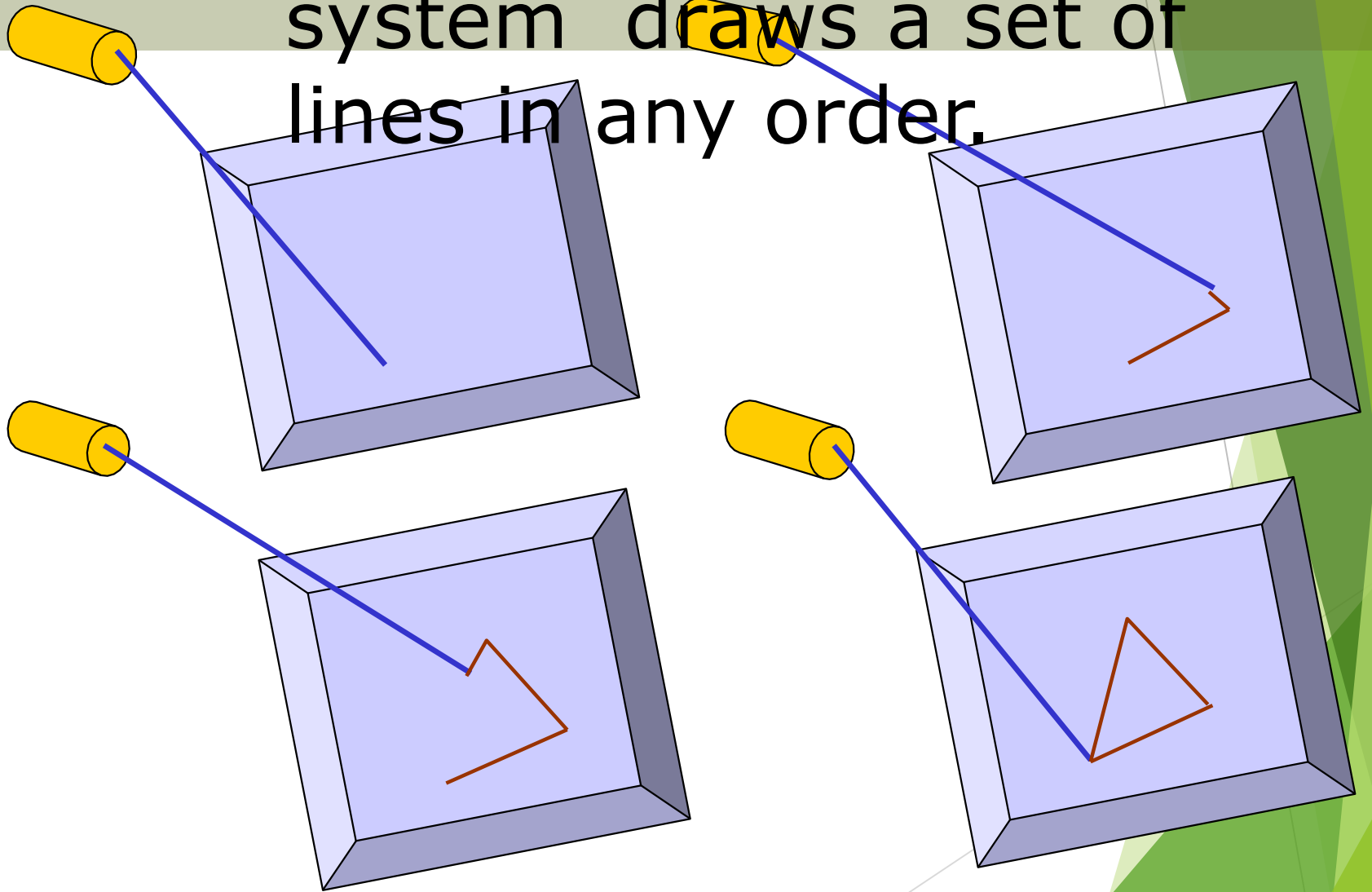
Conceptual block diagram of calligraphic refresh display - II

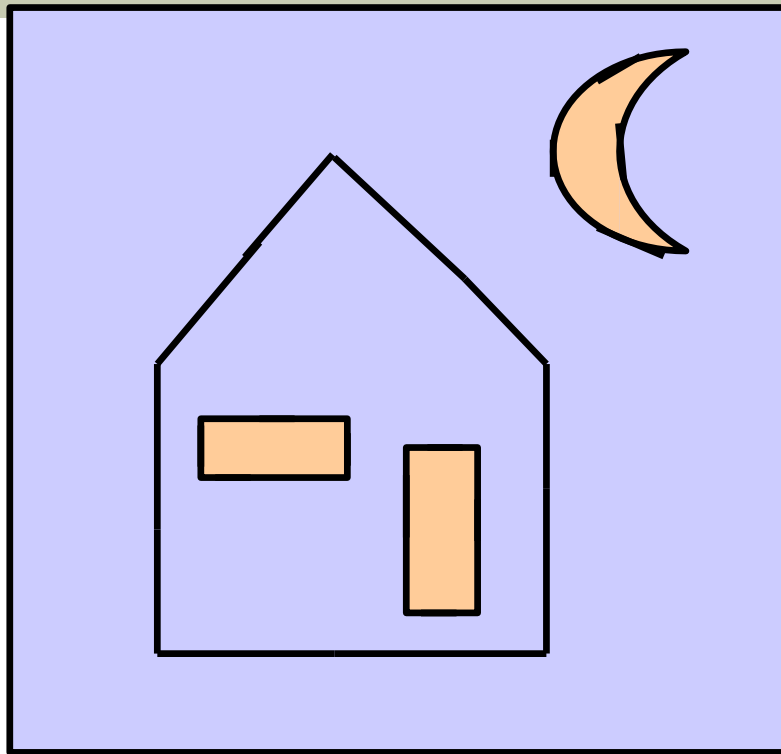


Calligraphic or Random Scan display system (contd.)

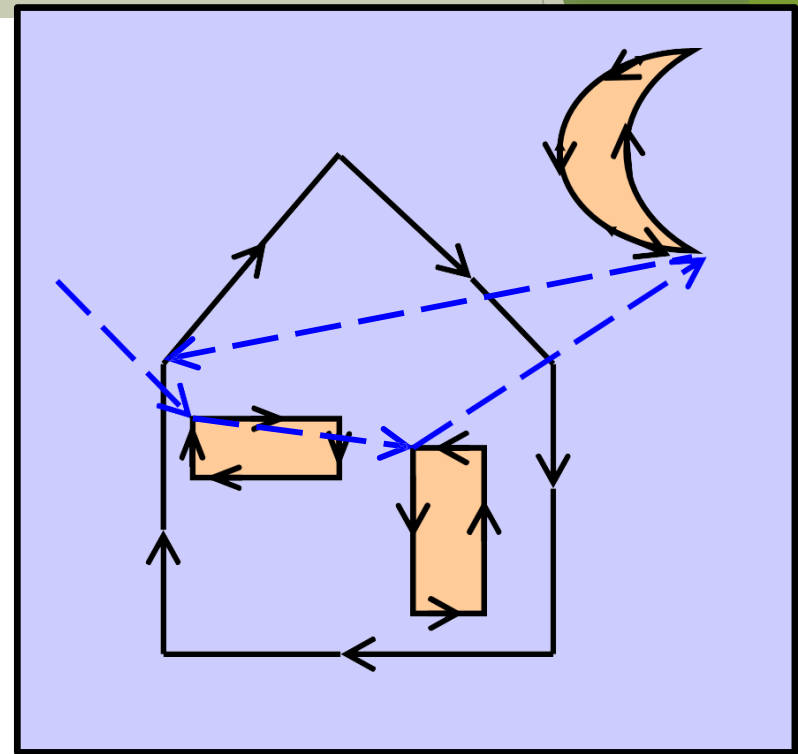
- **The display processor sends digital and point coordinate values to a vector generator**
- **The vector generator converts the digital coordinate values to analog voltages for the beam-deflection circuits**
- **The beam-deflection circuits displace the electron beam for writing on the CRT's phosphor coating**
- **Recommended refresh rate is 40 – 50 Hz.**
- **Scope of animation with segmentation – mixture of static and dynamic parts of a picture**

Random-scan display
system draws a set of
lines in any order.





(a) Ideal line drawing



(b) Vector scan

Calligraphic or Random Scan display system (contd.)

- **Phosphor's Fluorescence** is the light emitted as electrons (unstable) lose their excess energy while the phosphor is being struck by electrons

Phosphorescence is the light given off by the return of the relatively more stable excited electrons to their unexcited state once the electron beam excitation is removed

- **Phosphor's persistence** is defined as the time from the removal of excitation to the moment when phosphorescence has decayed to 10% of the initial light output (decay is exponential).

- long persistence : several seconds

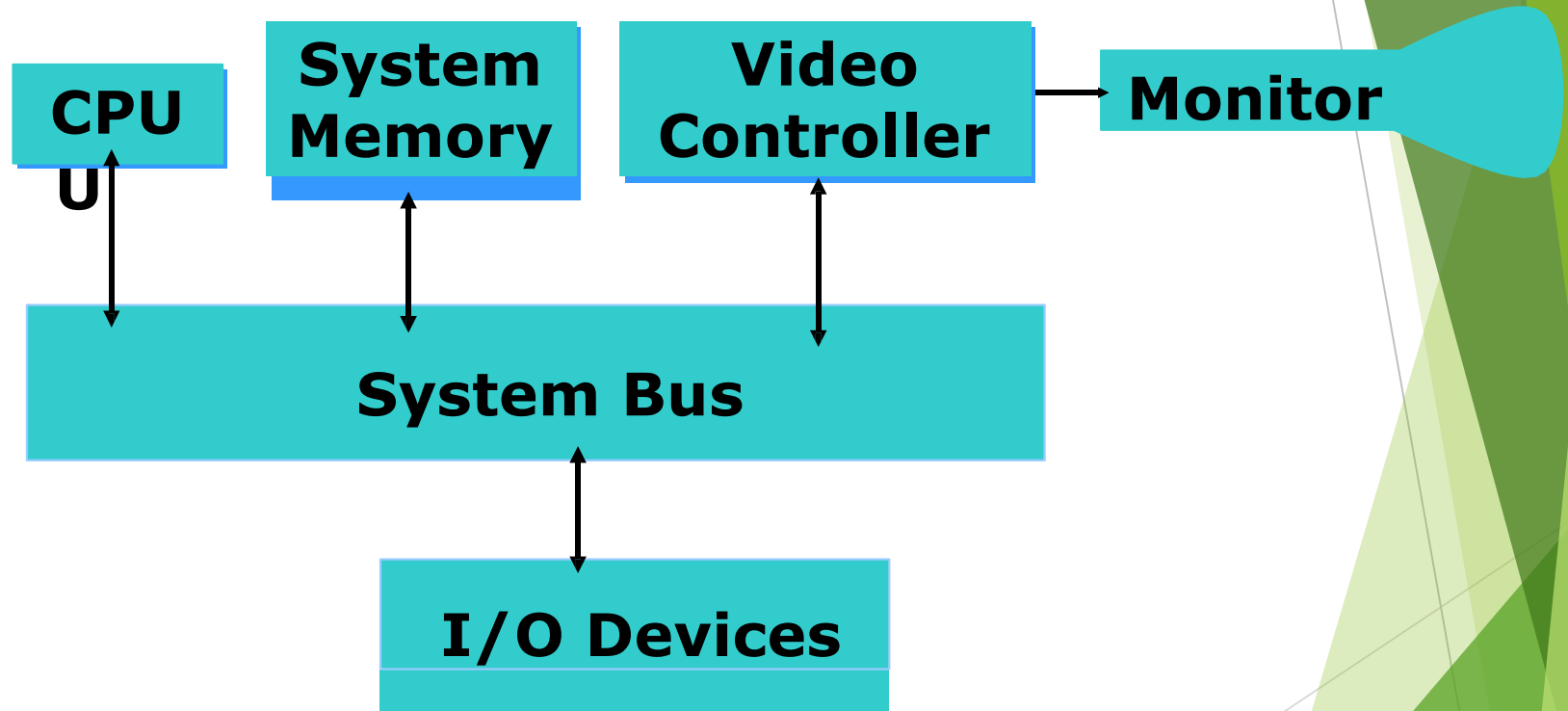
- short persistence : 10-60 μs

(common in modern displays)

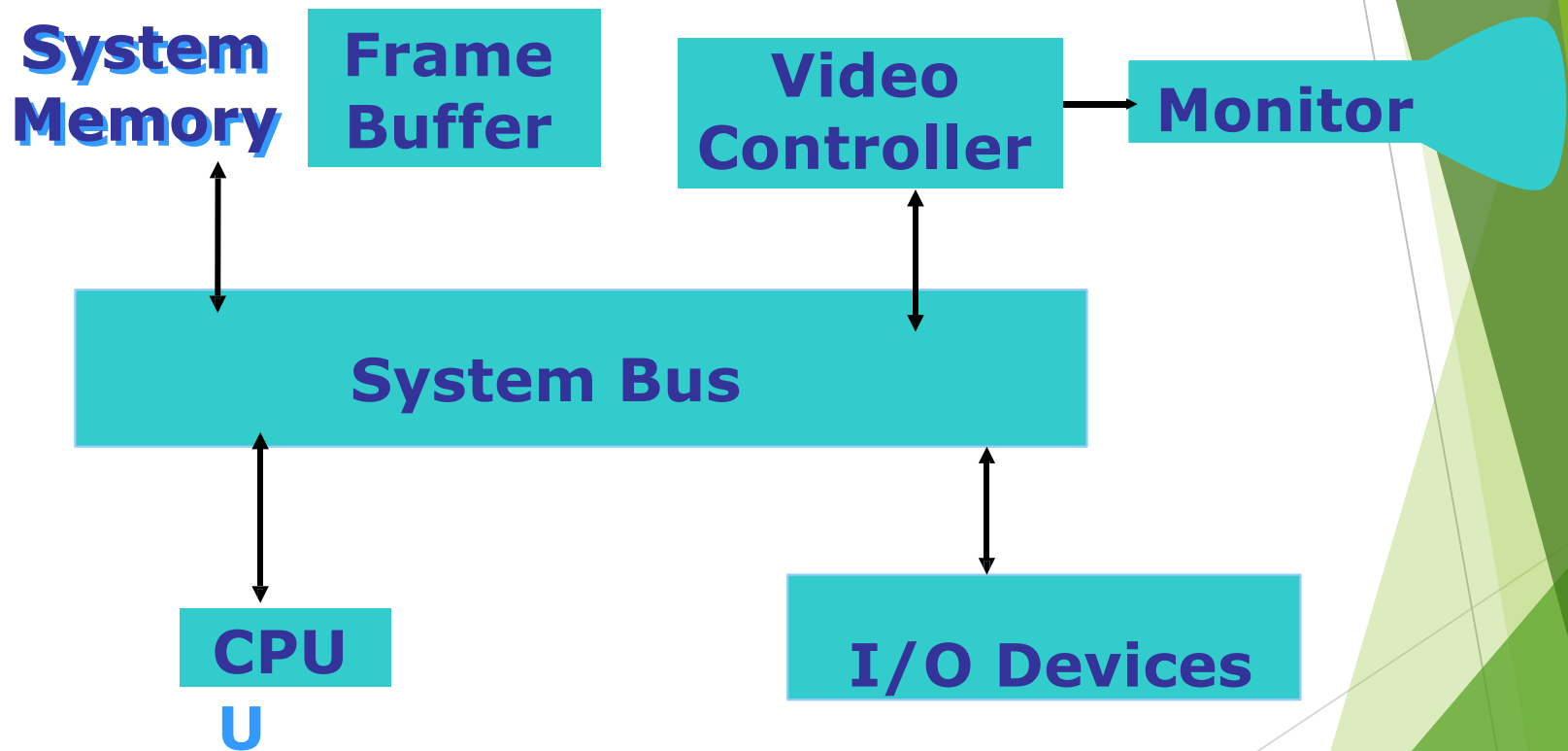
Refresh and raster scan display system

- **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 (also called frame buffer) stores the drawing primitives in terms of points and pixels components**

Architecture of a simple raster graphics system



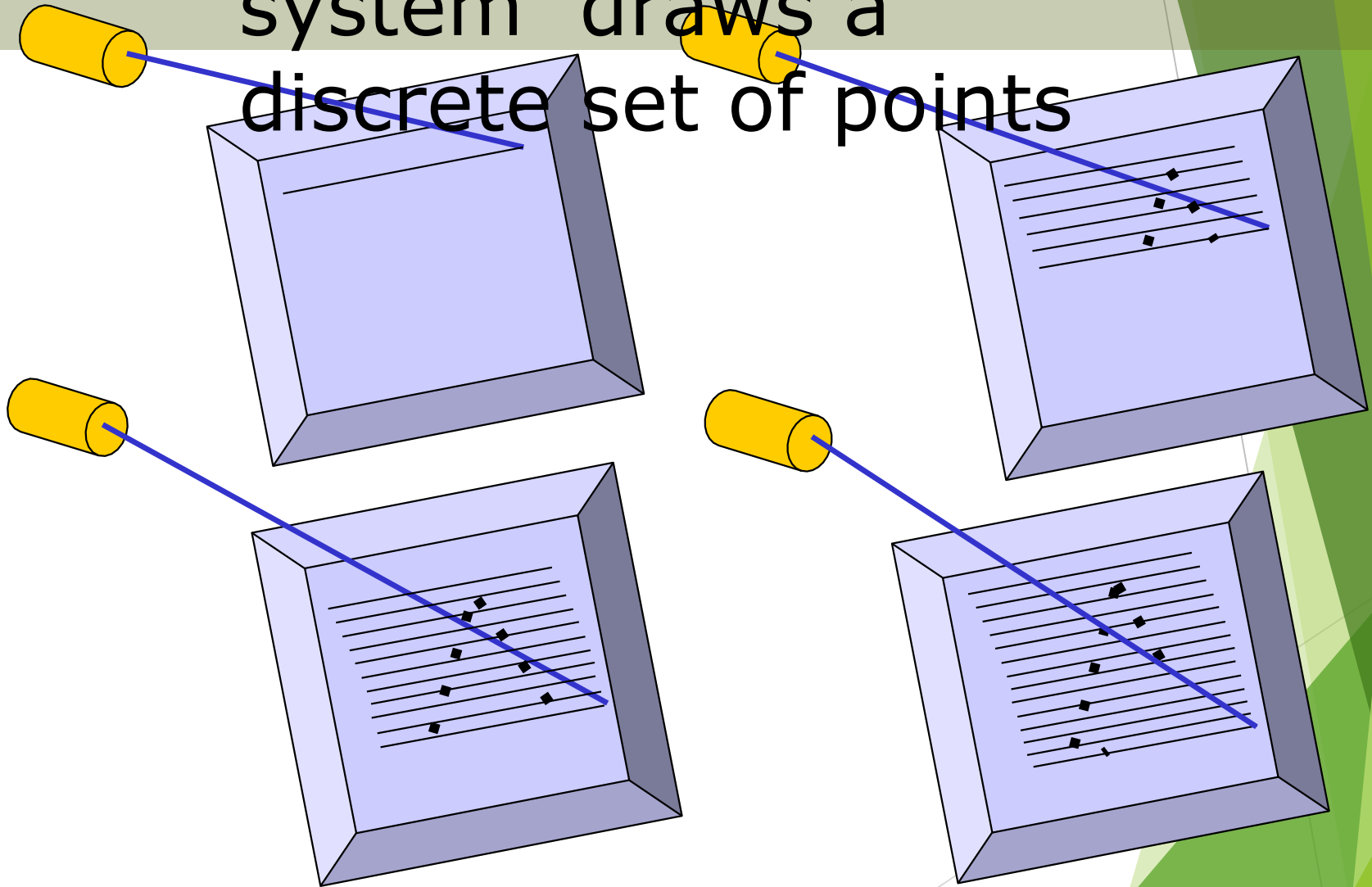
Architecture of a raster system with a fixed portion of the system memory reserved for the frame buffer



Refresh and raster scan display system (contd.)

- **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 causes the effect of 'aliasing', 'jaggies' or 'staircase' effect**
- **Refresh/Frame buffer is also called Bit-plane**

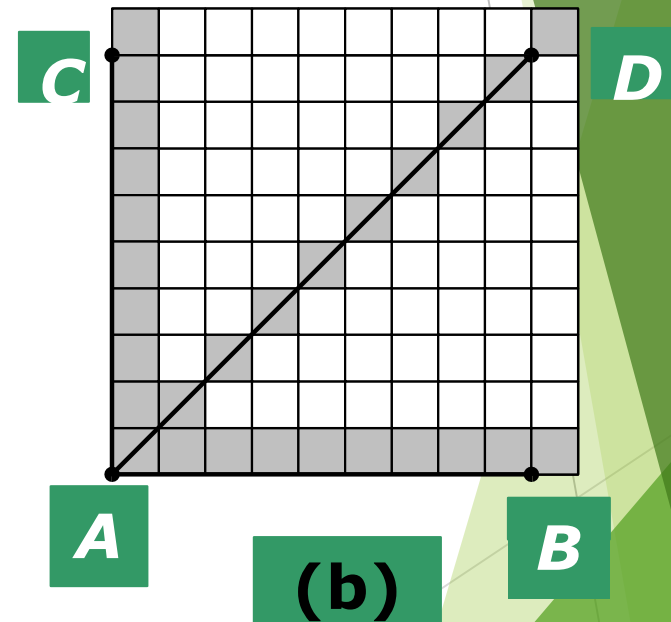
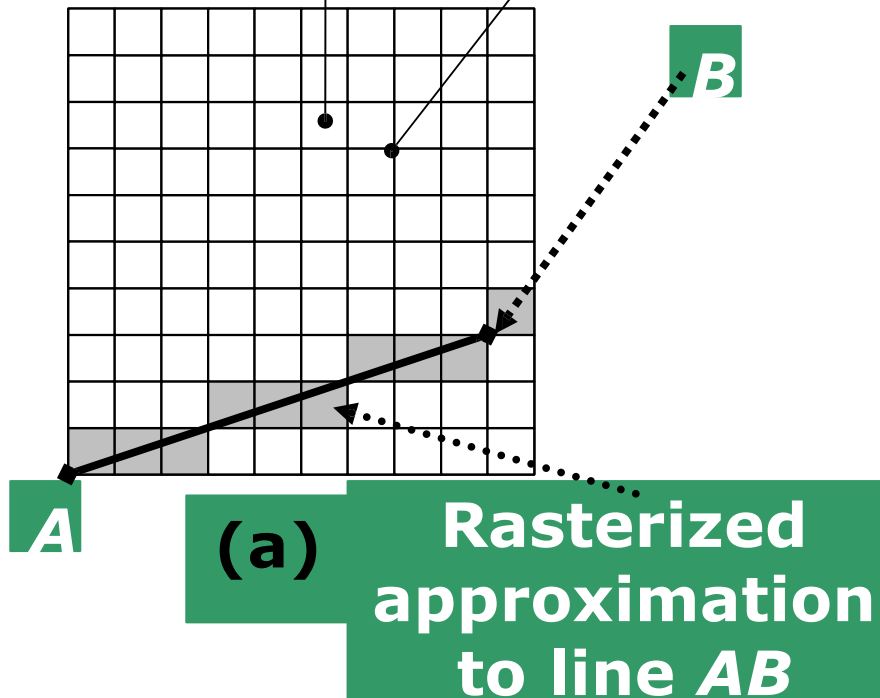
Raster-scan display
system draws a
discrete set of points



Rasterization: (a) General line ; (b) special cases

Picture
element,
or pixel

Addressable
point



Refresh Rate, Video basics and Scan Conversion

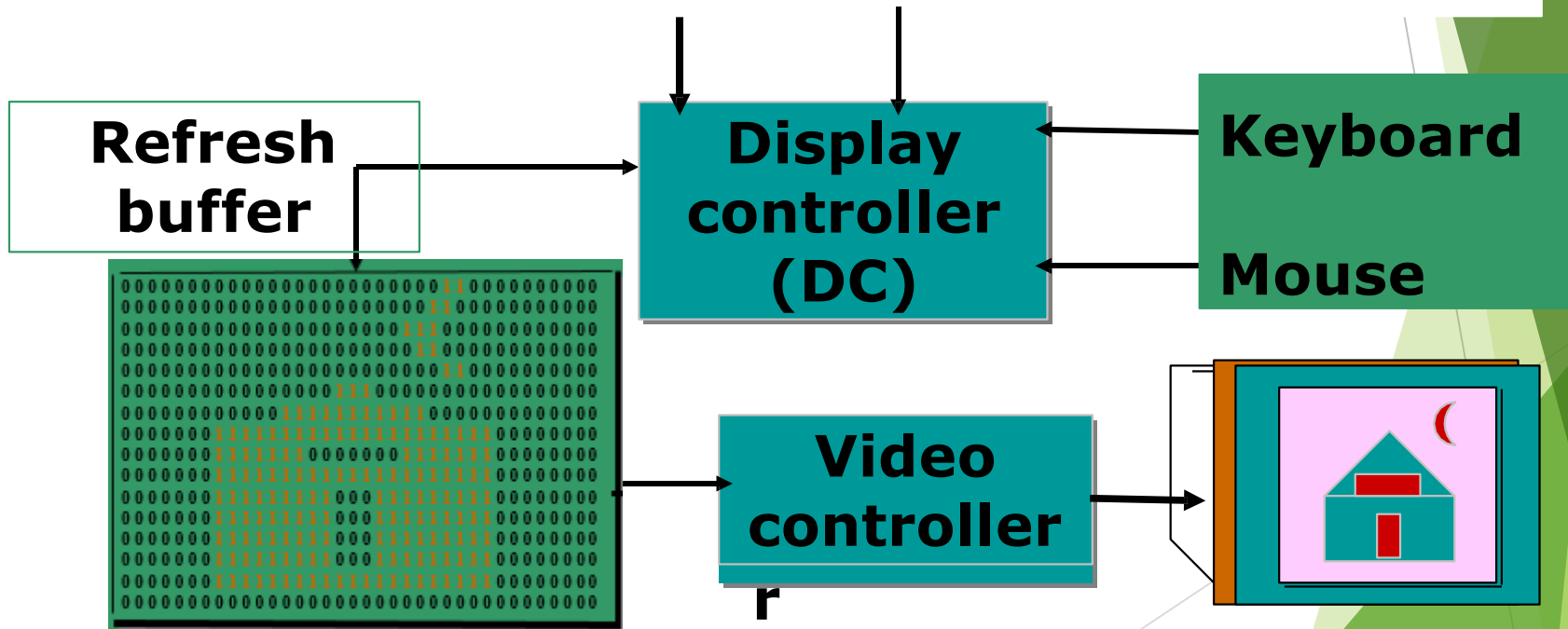
- **Raster is stored as a matrix of pixels representing the entire screen area**
- **Entire image is scanned out sequentially by the video controller (one raster line at a time)**
- **The raster lines are scanned from top to bottom and then back to the top**
- **The intensity of the beam decides the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

Architecture of a raster display

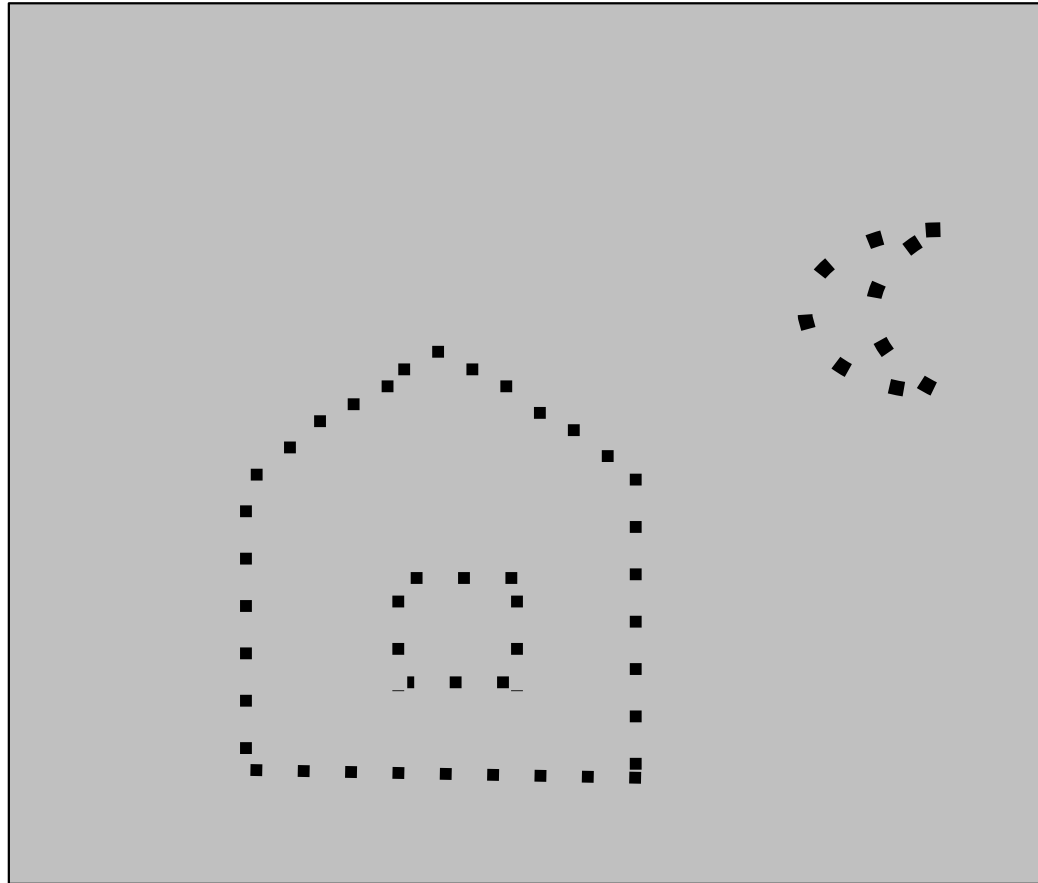
Interface with host computer

(Display commands)

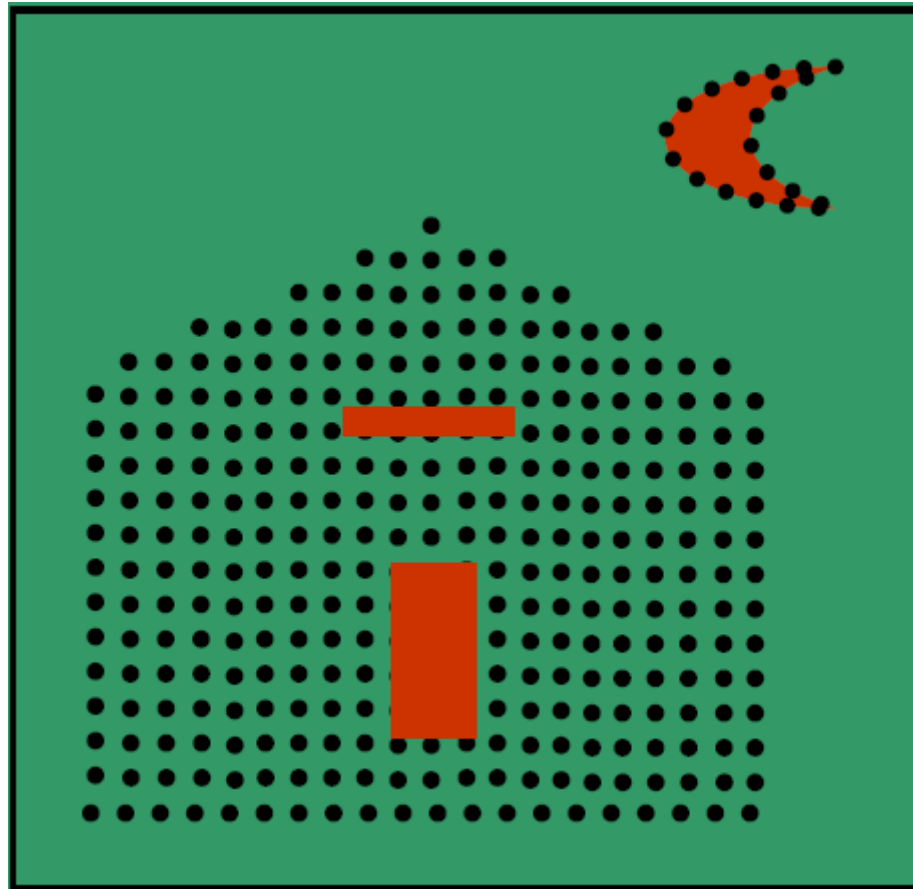
(Interaction data)



Raster scan with outline primitives



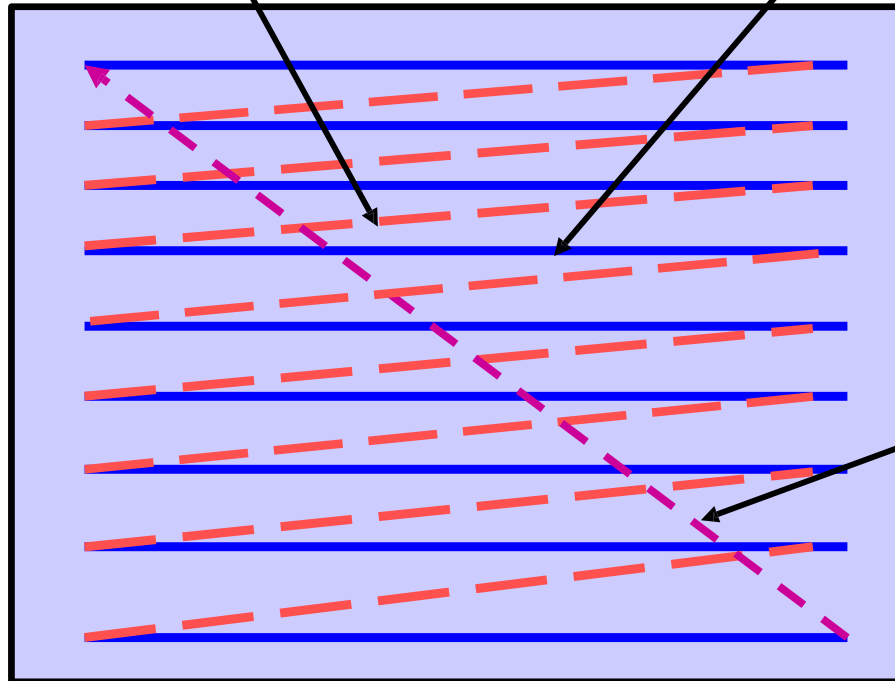
Raster scan with filled primitives



Raster Scan

**Horizontal
retrace**

Scan line



**Vertical
retrace**

Refresh Rate, Video basics and Scan Conversion (contd.)

NTSC (American Standard Video) has 525 horizontal lines with a frame rate of 30 fps.

Viewing aspect ratio is 4:3

- **Each frame has two fields, each containing half the picture.**
- **Fields are interlaced or interwoven**
- **Fields are presented alternately every other $1/60$ -th of a sec.**
- **One field contains odd scan lines (1,3,5,...)**
- **The other contains even scan lines (2,4,6,...)**
- **Two types of retrace after every field**

Interlacing scan lines on a raster scan display;
First, all points on the even-numbered (solid)
scan lines are displayed; then all points along
the odd-numbered (dashed) lines are
displayed

