CS 402:
Computer Graphics

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CS 402: Computer Graphics

Lecture Note 02

Ch. 2: Display Technologies

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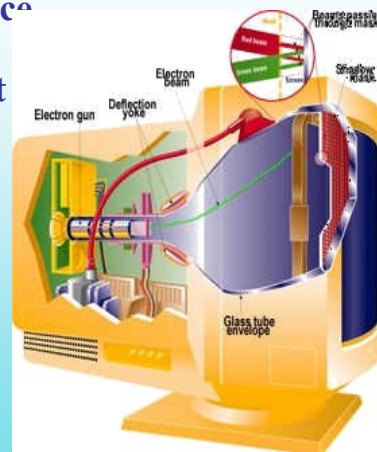# CS402: Computer Graphics

Lecture 2: Display Technologies

- CRT Monitors
- Raster Displays
- Raster Display Systems
- Vector Displays
- Flat-Panel Displays

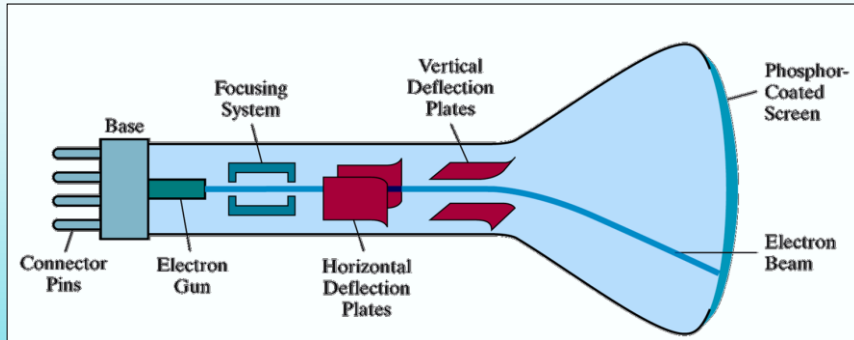- **Materials:** Hearn & Baker - **Chap 2, pp. 36-48, 53-56 (study)**

Cathode Ray Tubes (CRTs)

- **Most common display device today**
- **Evacuated glass bottle (last remaining vacuum tube)**
- **Heating element (filament)**
- **Electrons attracted to focusing anode cylinder**
- **Vertical and Horizontal deflection plates**
- **Beam strikes phosphor coating on front of the screen**

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Cathode Ray Tubes (CRTs)

Vertical Deflection Plates

Focusing System

Base

Phosphor-Coated Screen

Connector Pins

Electron Gun

Horizontal Deflection Plates

Electron Beam

Vector Displays

- **Oscilloscopes were some of the 1st computer displays used by both analog and digital computers.**
- **Computation results used to drive the vertical and horizontal axis (X-Y)**
- **Used mostly for line drawings Called vector, calligraphic or stroker displays**
- **Line drawings are stored in a file called the display list that is used to refresh the screen.**
- **Display list had to be constantly updated.**

Vertical Deflection

Horizontal Deflection

Focusing System

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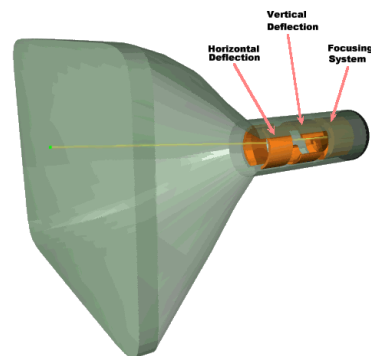
Vector Displays
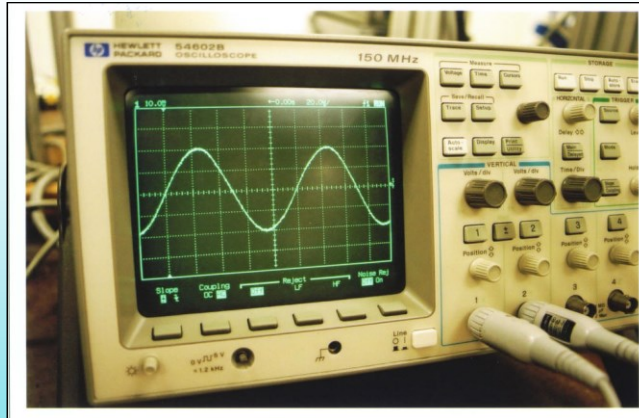
Oscilloscope

Raster Displays

- **B/W TVs are basically oscilloscopes (with a hardwired scan pattern)**
- **Entire screen painted 30 times/sec**
- **Screen is traversed 60 times/sec**
- **Even/Odd lines on alternate scans (called fields)**
- **Interlace - a hack to give**
  - **Smooth motion on dynamic scenes**
  - **High resolution on static scenes**
- **Now: Non-interlaced monitors are available.**

Raster Scan Pattern of Interlaced Display
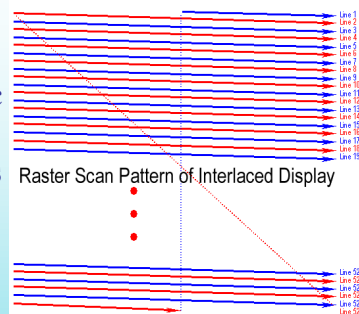
Interlaced Raster Display

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Raster Display

- ## In a raster display
  - **The path of the electron beam is hardwired, it scans one row (scan-line) at a time.**
  - **The computer must synchronize its "painting" of the screen with the scanning of the display.**
  - **The computer only controls the intensity of the color at each point (pixel) on the screen.**
  - **Usually a dedicated section of memory, called the frame buffer, is used to store these intensity variations.**

Raster Display

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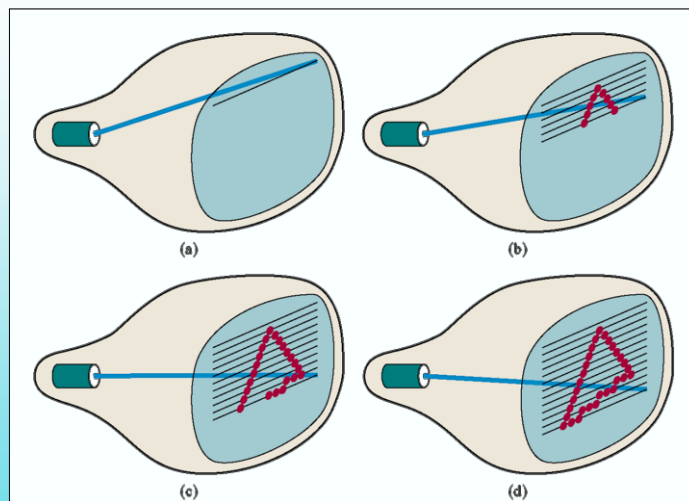
Some Definitions

- **Persistence of phosphor:**
  - The time taken so that the emitted light from the phosphor to decay to one tenth of its original intensity.
  - Lower persistence phosphors require higher refresh rate to maintain picture on screen without flickering
- **Pixel (Picture Element):**
  - A screen point.

Some Definitions

- **Screen Resolution:**
  - The maximum number of pixels that can be displayed on the screen.
- **Refresh Buffer (Frame Buffer):**
  - A memory area that holds a set of intensity values for every screen point (All pixels).
- **Aspect ratio:**
  - The ratio of the vertical pixels to horizontal pixels necessary to produce equal-length lines in both direction on the screen.

Some Definitions

- **Bitmap:**
  - The **frame buffer** of a B/W screen
- **Pixmap:**
  - The **frame buffer** of a color screen
- **Refresh Rate:**
  - The time taken by the electron beam to scan the whole screen.

Raster-scan displays are usually refreshed at 60 to 80 frame/sec (fps) – some systems are designed for higher refresh rate.

Some Definitions

- **Horizontal Retrace:**
  - The time taken by the e-beam to return from the end of a **scan line** to the beginning of the **next** scan line.
- **Vertical Retrace:**
  - The time taken by the e-beam to return from the end of the **last** scan line to the beginning of the **first** scan line.
- **Display Controller/Video controller**
  - Is used to control the operation of the display device.

Some Definitions

- **Display Processor/Graphics controller**
  - **A separate processor to carry out the graphics tasks, i.e digitizing (scan converting) an picture in an application into a set of pixel intensity values for storage into the frame buffer. (To free the CPU for other tasks)**
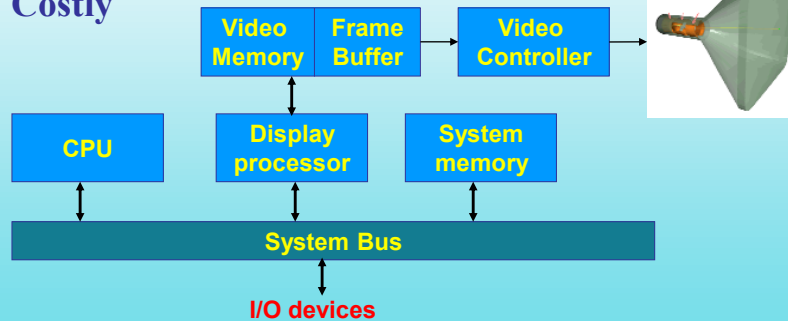
A simple Raster Display System

- **A fixed area of the system memory is reserved for the frame buffer.**

| CPU | System memory | Frame Buffer | Video Controller |

System Bus

I/O devices

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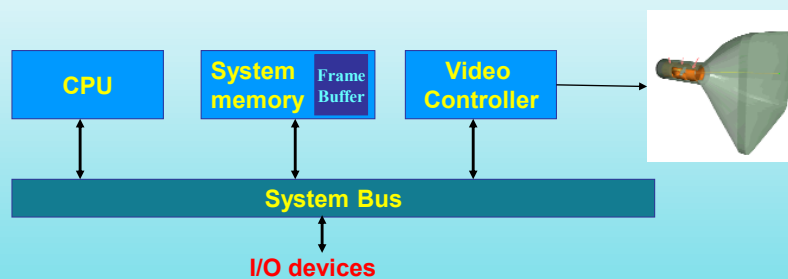
High-End Graphics Display System

- **Adds a second frame buffers. One is used to refresh the screen while the other is being filled.**
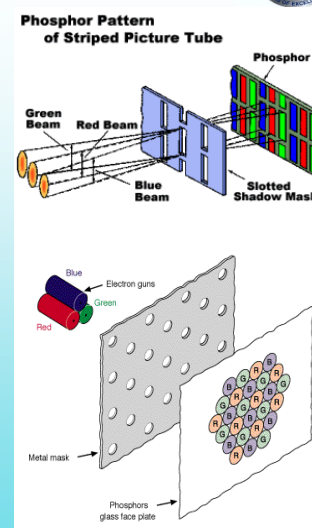- **A separate display processor/graphics controller**
- **Costly**

Color Video

Color CRTs are much more complicated

- **Requires precision geometry**
- **Patterned phosphors on CRT face**
- **Aligned metal shadow mask**
- **Three electron guns**
- **Less bright than monochrome CRTs.**

Raster Display

Disadvantages:

- Requires screen-sized memory array
- Discrete spatial sampling (pixels)
- Limit on practical size (< 40 inches)
- Spurious X-ray radiation
- Occupies a large volume

Advantages:

- Allows solids to be displayed
- Leverages low-cost CRT H/W (TVs)
- Whole Screen is constantly updated
- Bright light-emitting display technology

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# Other Display Technologies

- **Flat-Panel Displays**
  - Refer to the types of monitors that have reduced volume, weight, and power requirements compared to CRTs.
  - Two types:
    - **Emissive displays (emitters)**
      - *Devices that convert electrical energy into light* (e.g., plasma panels, thin-film electroluminescent, and light-emitting diodes).
    - **Non-emissive displays (non-emitters)**
      - *Use optical effects to convert sunlight or light from other sources into graphics patterns* (e.g., Liquid-crystal device, LCD).

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Liquid Crystal Displays (LCDs)

- **When LCDs are used as optical (light) modulators they are actually changing polarization rather than transparency.**

- **LCDs rotate the polarization of light by 90 degrees in the presence of an electric field acting as a closed/open window for the polarized light.**

Liquid Crystal Displays (LCDs)
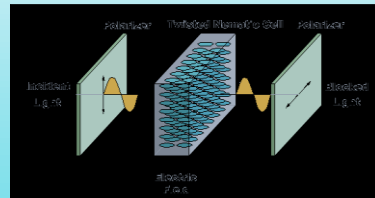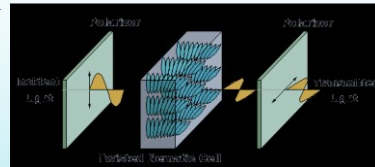
The LCD's transition between crystalline and liquid states is a slow process. This has both good and bad side effects. LCDs, like phosphors, remain "on" for some time after the E field is applied. Thus the image is *persistent* like a CRT's, but this lasts just until the crystals can realign themselves, thus they must be constantly refreshed, again, like a CRT.
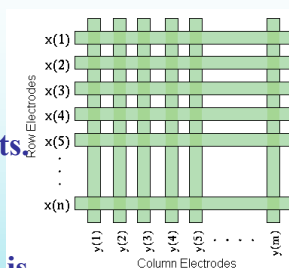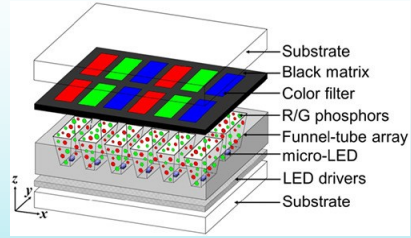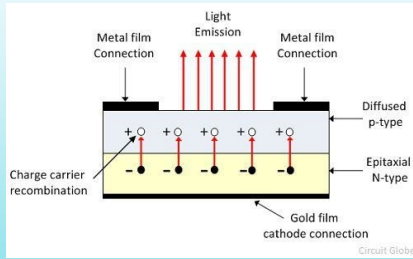

Passive matrix LCD display
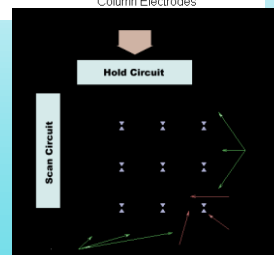
Active matrix LCD display

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Light Emitting Diodes(LEDs)

Homework

• **Solve problems number:**

  – **2-4, 2-5, 2-7, 2-10, 2-11, 2-12, and 2-13**

  (Submit your answers to TAs in the Lab)

Next Time

Color Models

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