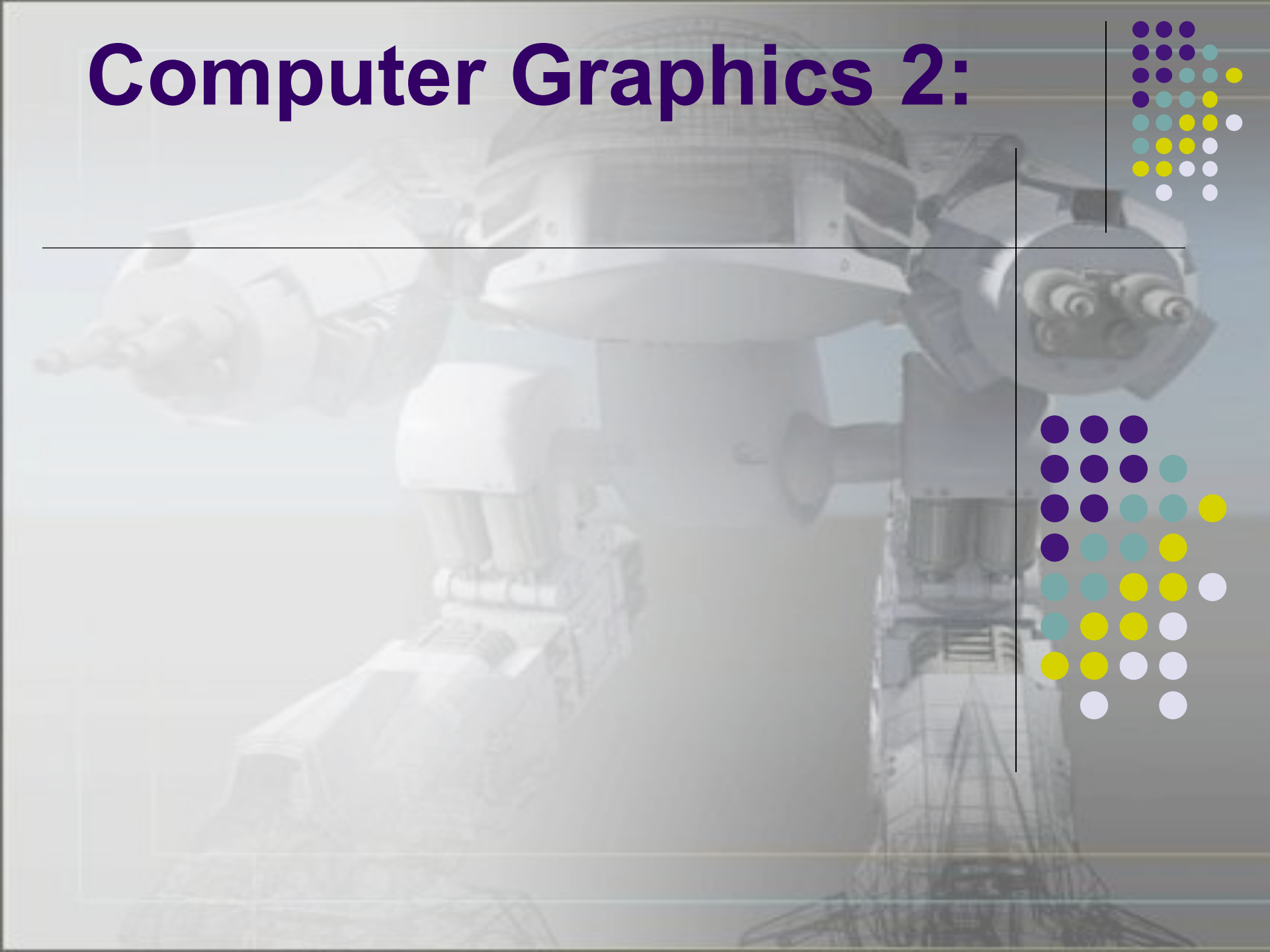
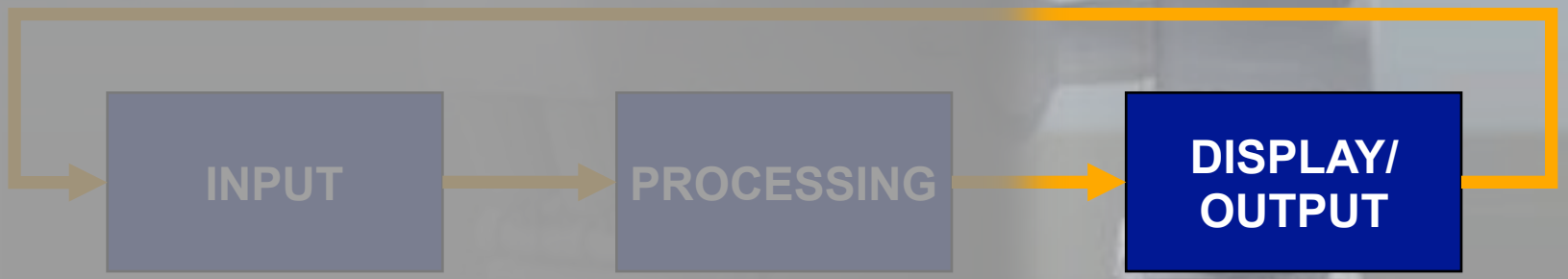
Computer Graphics 2:



Interactive Computer Graphics

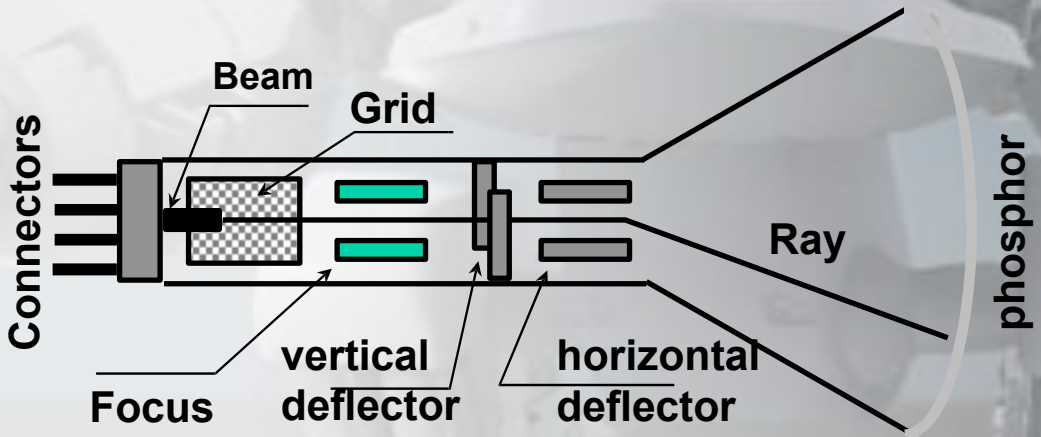


Mouse
Tablet and stylus
Force feedback device
Scanner
Live video streams

Screen
Paper-based printer
Video recorder
Projector
VR/AR headset

1.4 Characteristic devices: output

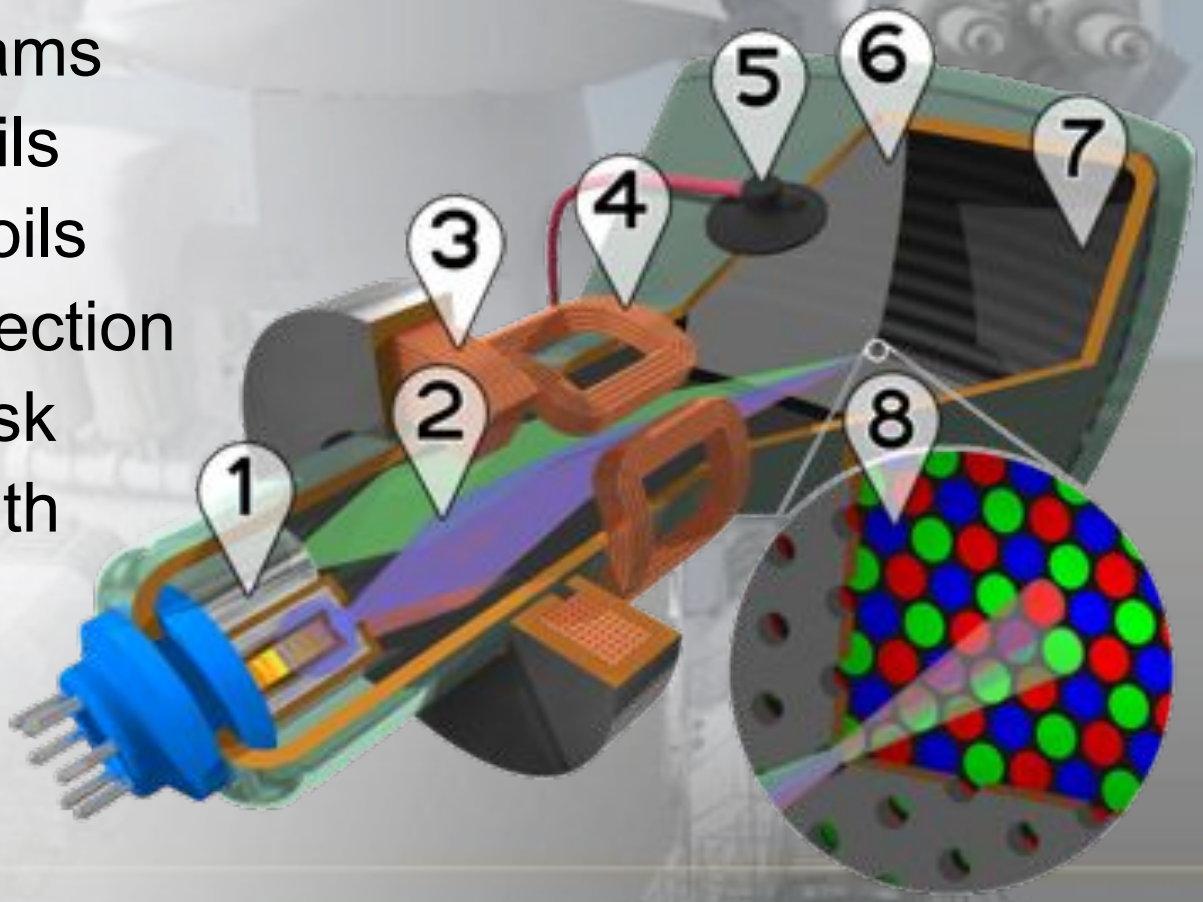
Graphic terminal: monitor + controller + memory



- CRT (Cathode Ray Tube) characteristics
  - The beam emits electrons (cathode).
  - Ray intensity is controlled by the grid.
  - The focus forces the electrons towards a convergence path.
  - Deflectors force the ray to point at a specific screen point.
  - The ray strikes the phosphor. Phosphor emits lights.
  - Phosphor emission declines very fast (screen refresh required)

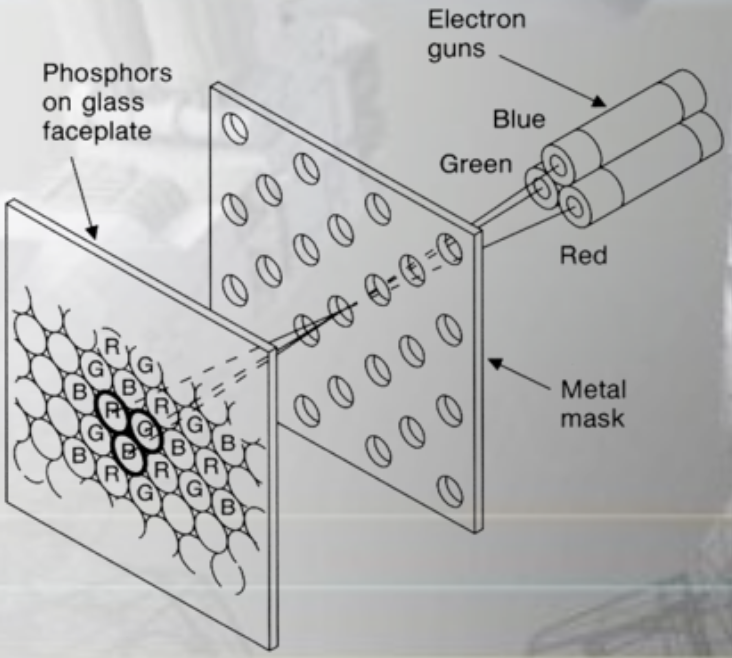
Color CRT

1) Electron guns
2) Electron beams
3) Focusing coils
4) Deflection coils
5) Anode connection
6) Shadow mask
7) Phosphor with RGB zones
8) Phosphor / Mask close-up



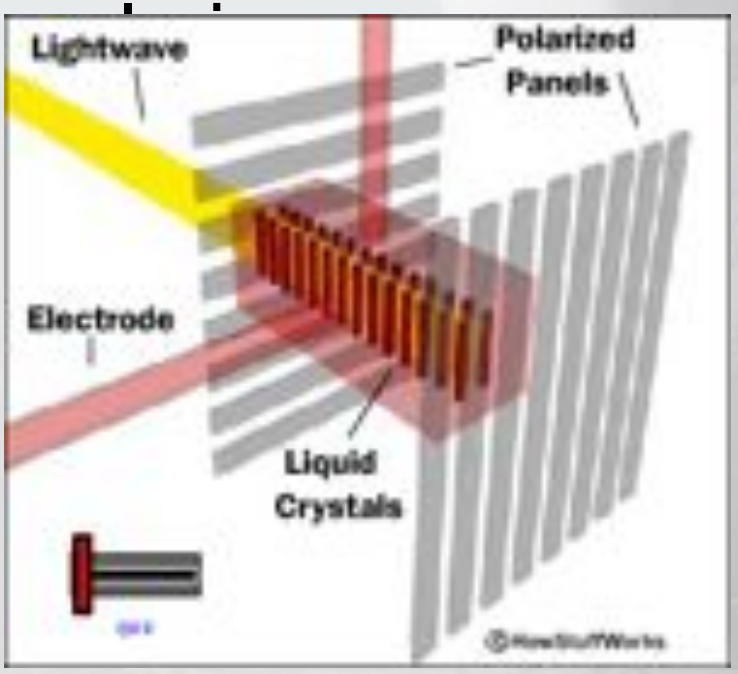
Color CRT

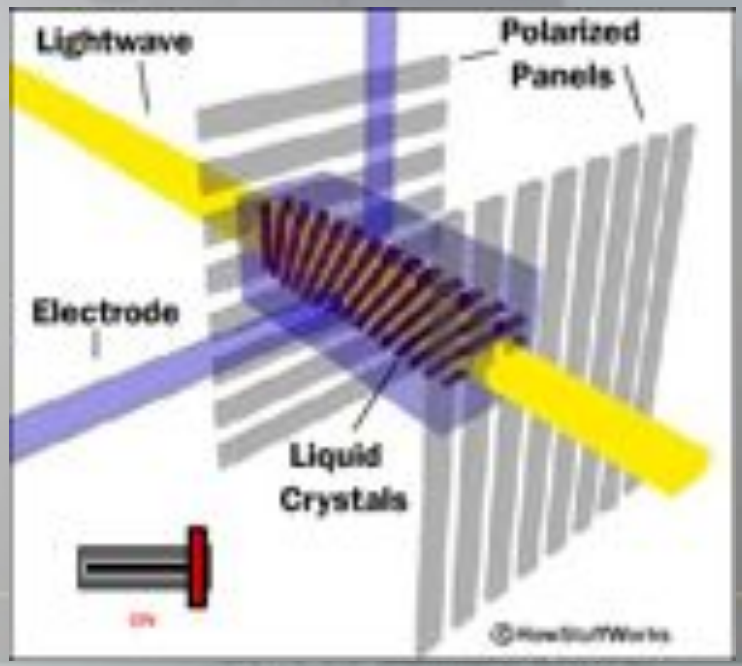
- Uses triads of red, green & blue at each pixel
- Uses 3 electron guns – one for each color
- Shadow mask used to make each kind of phosphor only visible from one gun



Liquid Crystal Display (LCD)

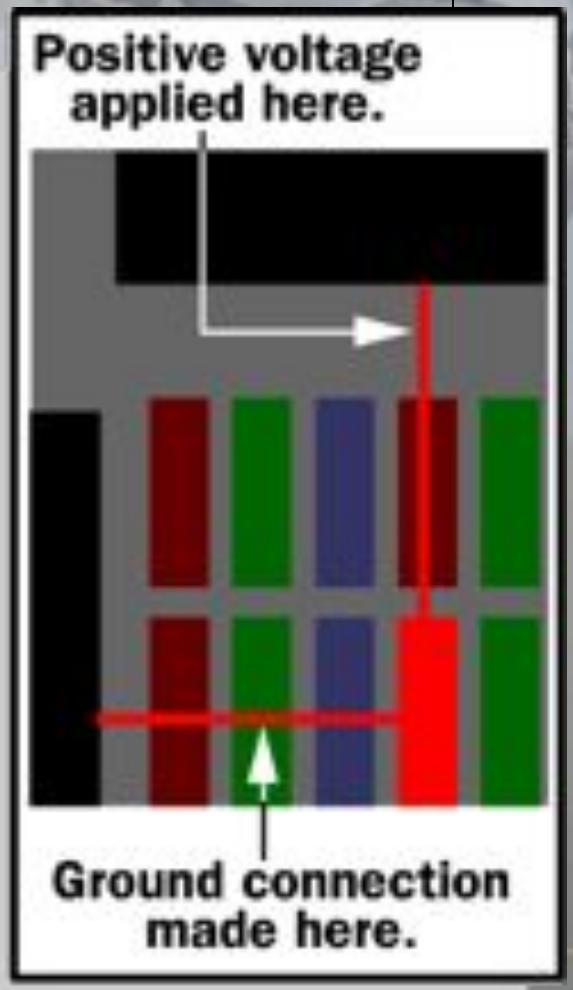
- Light enters polarizer
- Nematic crystals twist based on voltage
- Allowing light to pass through to other





Passive Matrix

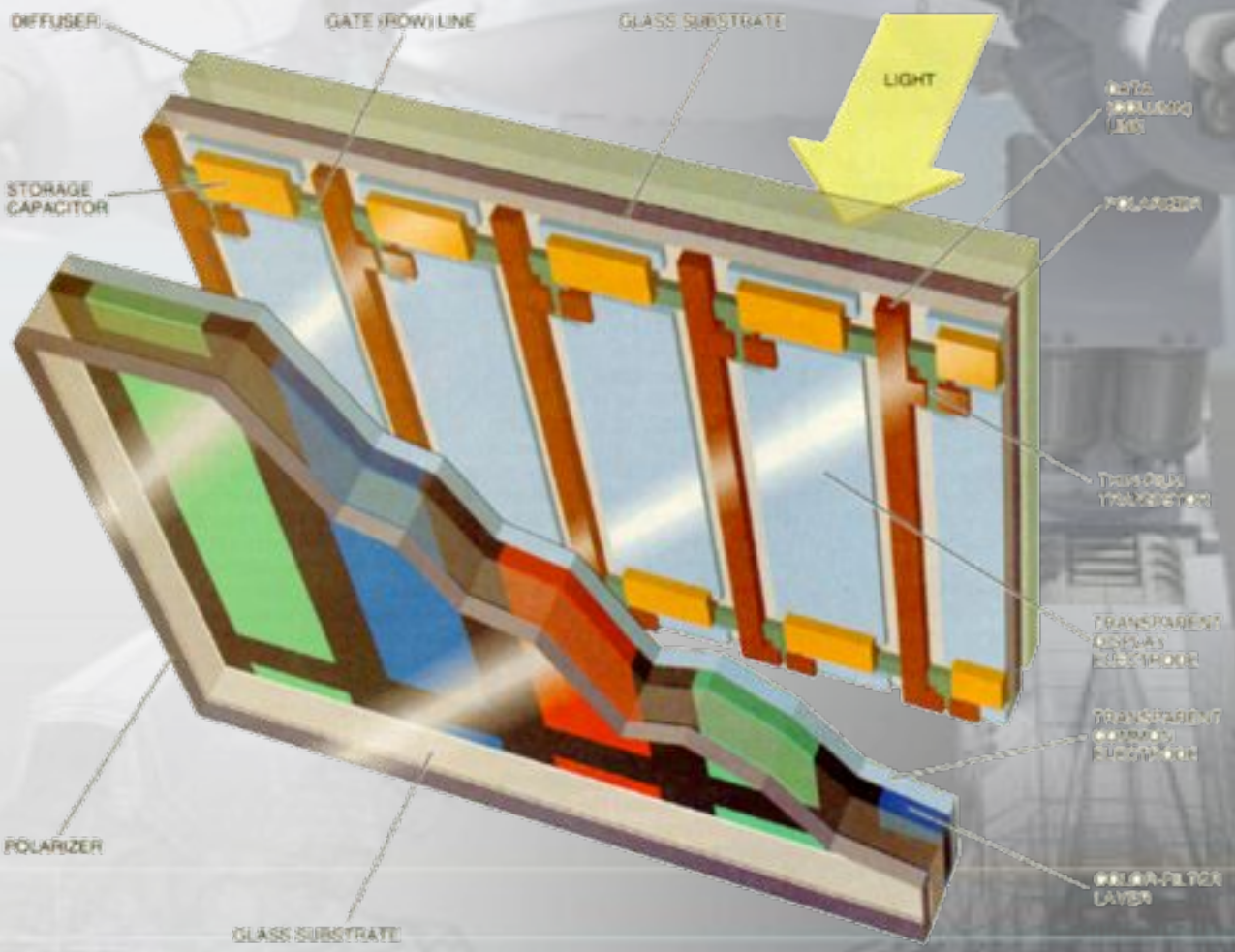
- Two glass layers
- One layer is given vertical transparent conductive material, the other is given horizontal
- Integrated circuit sends charge/ground activation to complete circuit at given row/column
- Simple, but slow response time



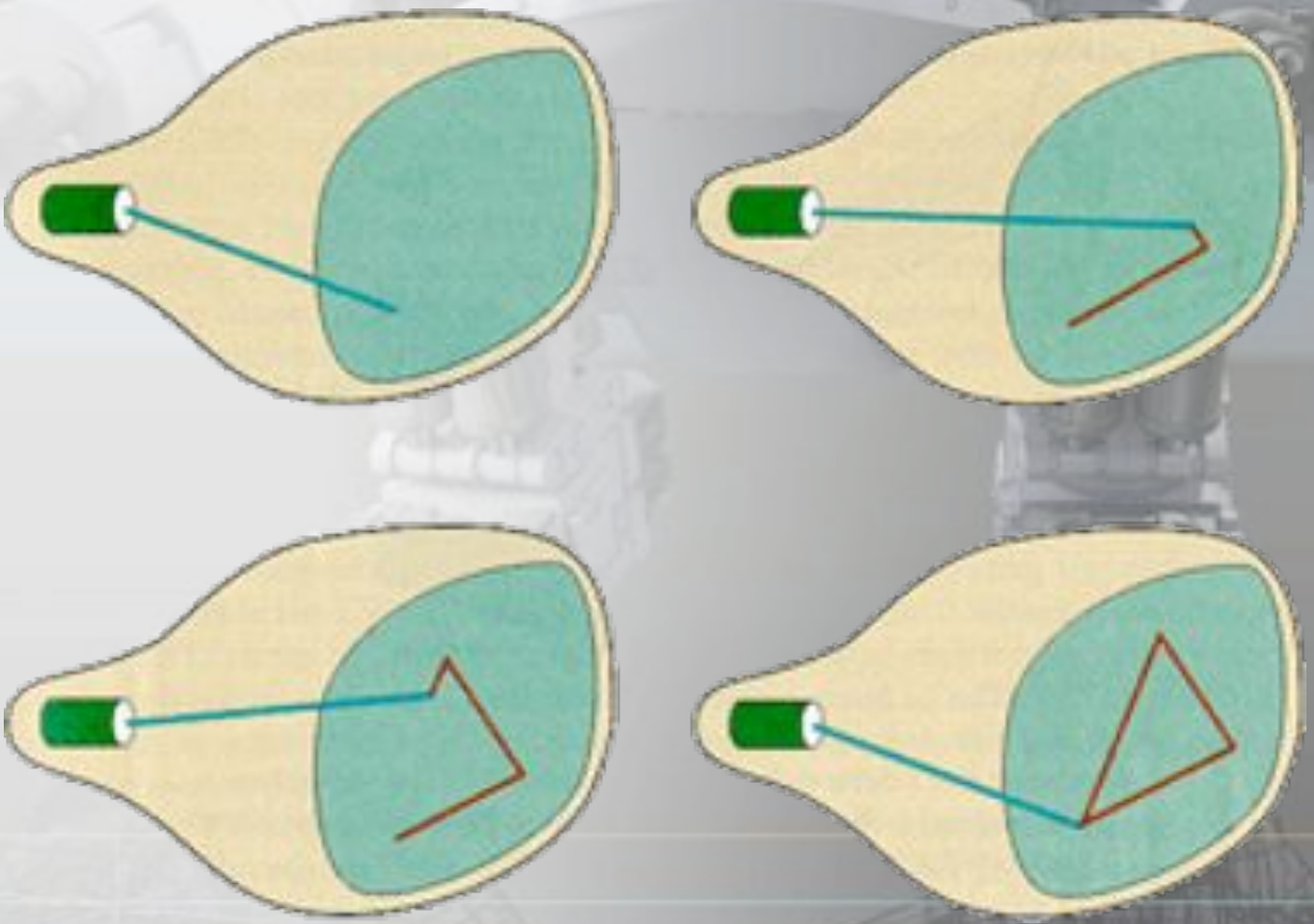
Active Matrix

- Active matrix displays have a transistor at each cell
  i. Thin film transistor (TFT)
- Much faster crystal switching

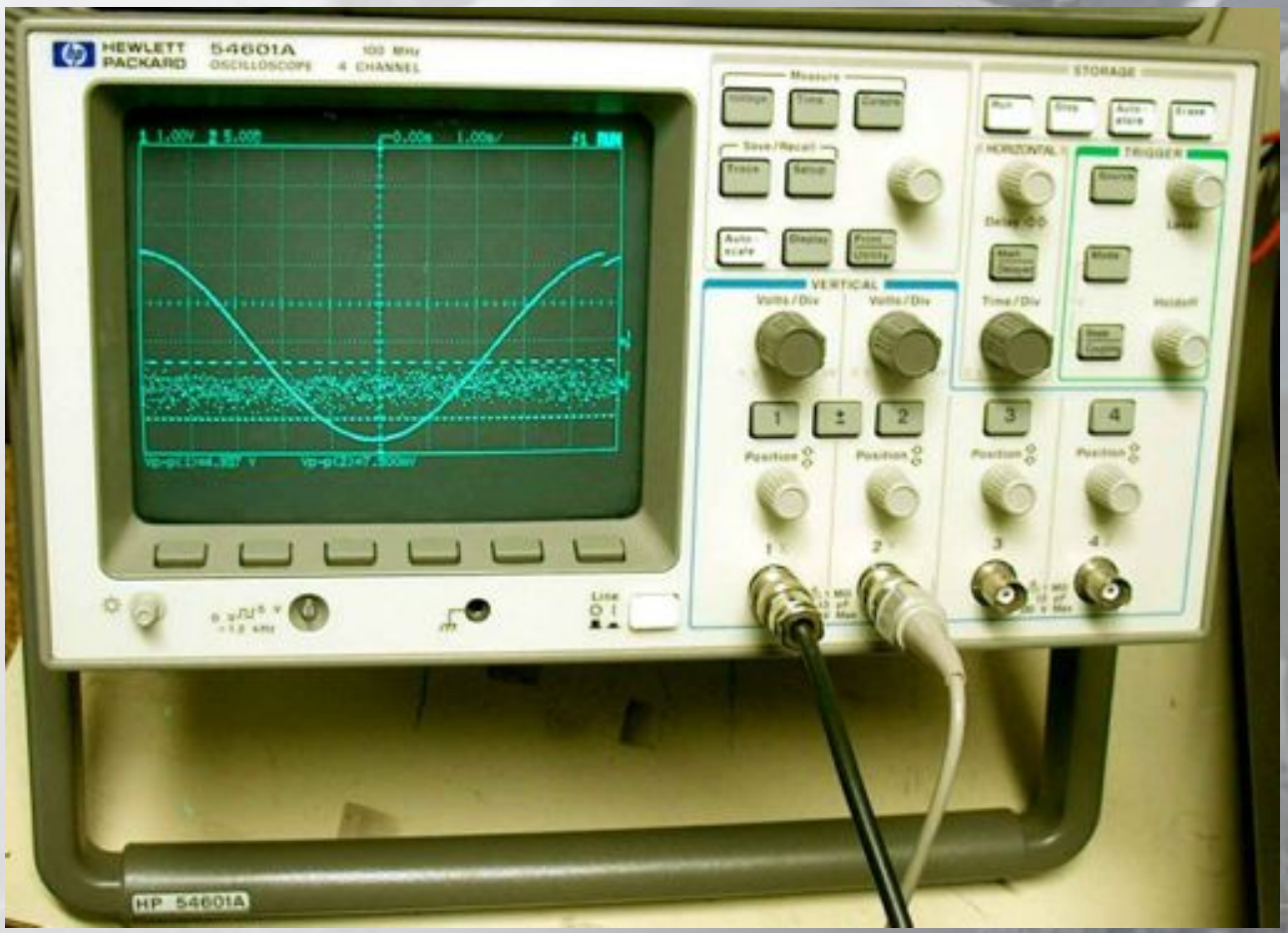
Color LCD


DIFFUSER
GATE (ROW) LINE
GLASS SUBSTRATE
LIGHT
STORAGE CAPACITOR
POLARIZER
GLASS SUBSTRATE

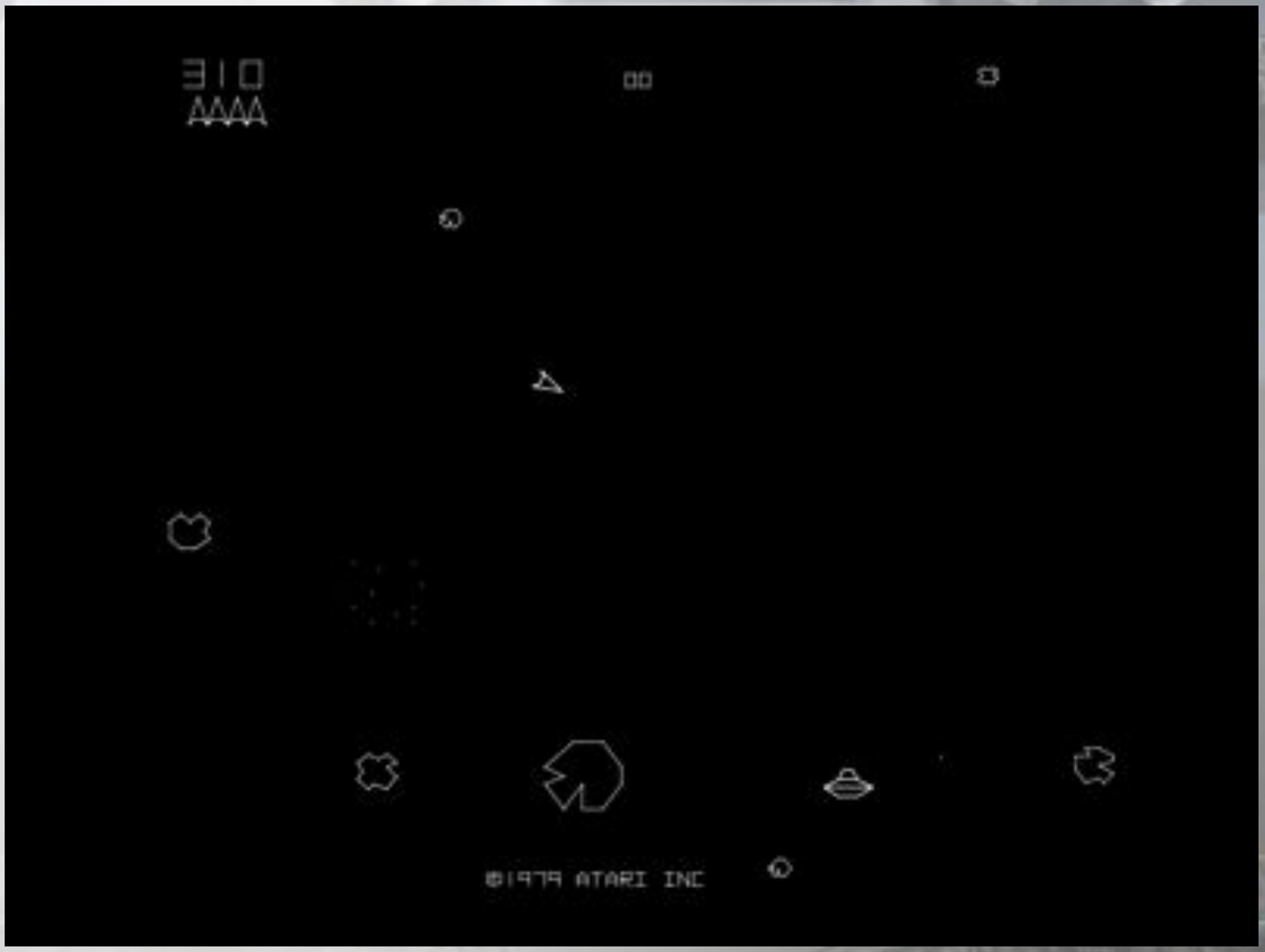
Random/Vector Display



Examples of Random Scan

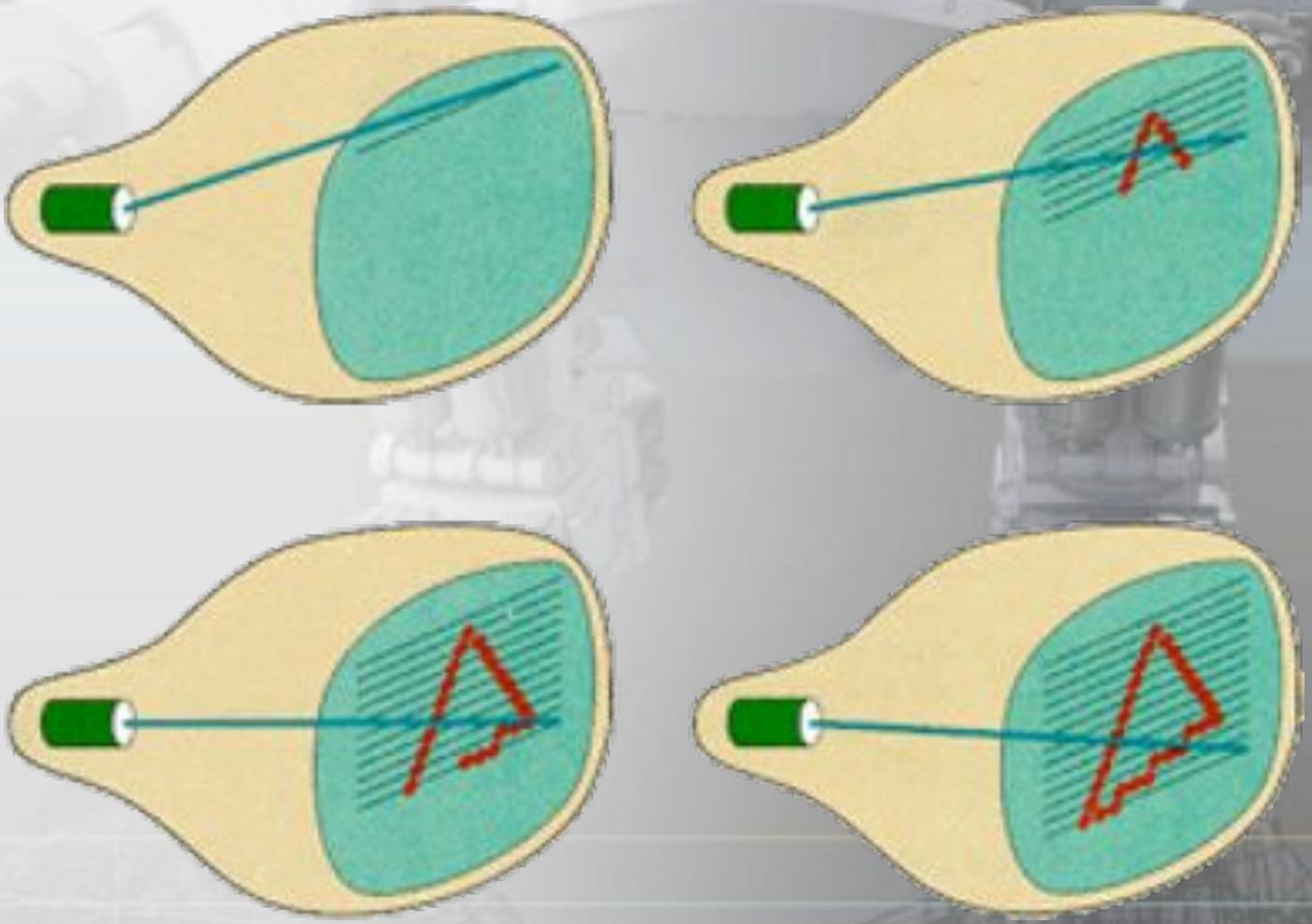


Examples of Random Scan

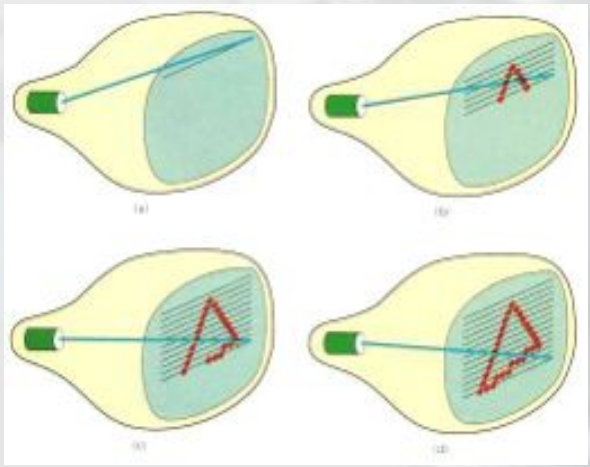


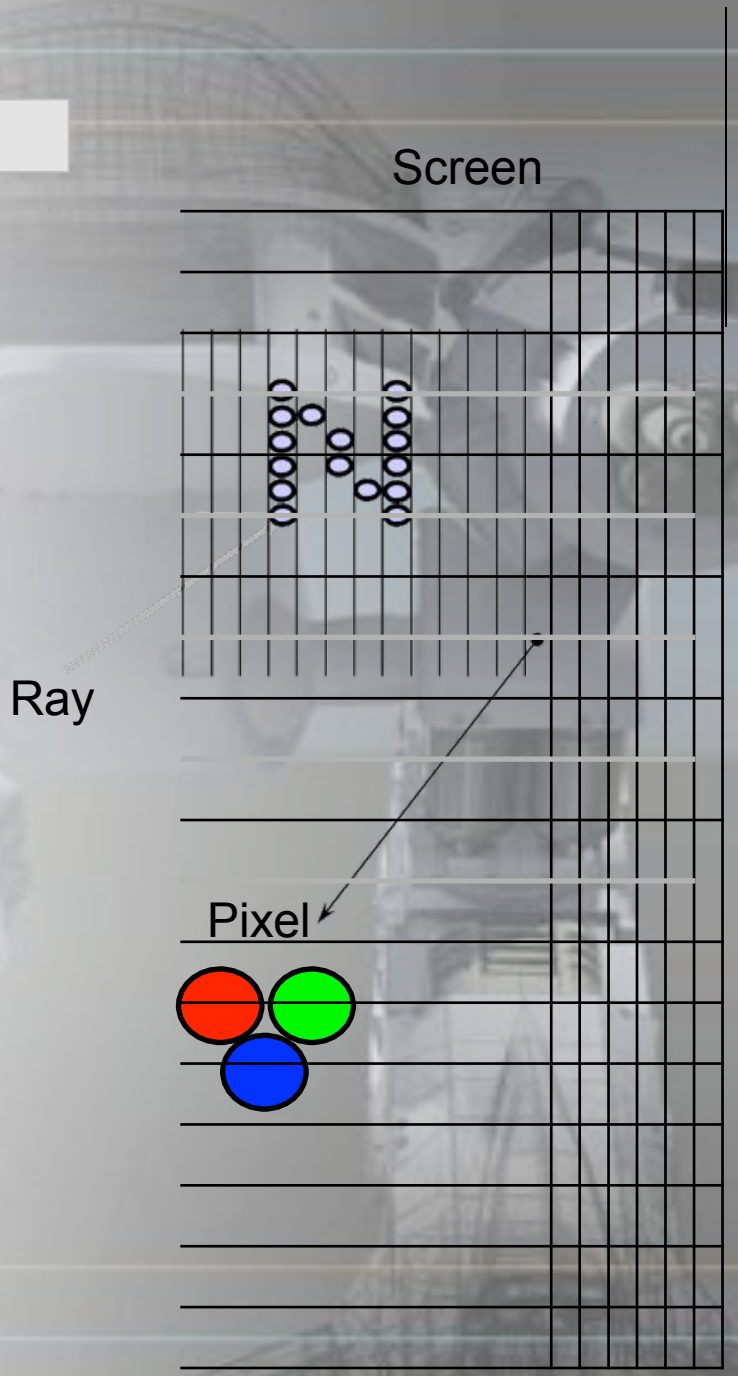
Examples of Random Scan

Raster Display



1.4 Characteristic devices: output





Raster Display

- Each left-to-right trace is called a scan line
- Each spot on the screen is called a pixel
- Beam turned off to swipe back and up screen
  i. Called a retrace or blanking interval

Vector vs. Raster

(a) Ideal line drawing

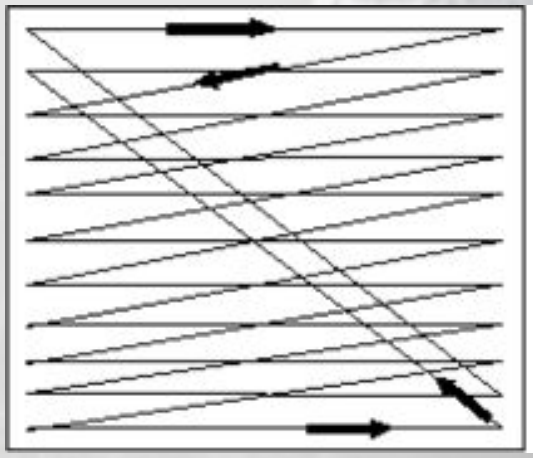
(b) Random scan

(c) Raster scan with outline primitives

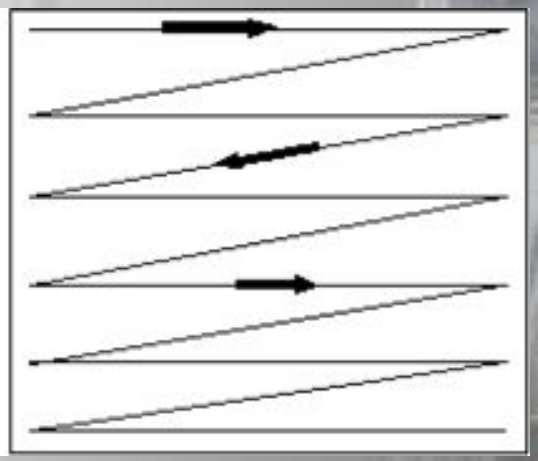
(d) Raster scan with filled primitives

Interlacing

- Interlacing is a technique used to improve video quality without additional bandwidth
  i. 480i (standard TV) is 480 scan lines, interlaced
  ii. 1080i HD is 1080 scan lines, interlaced
  iii. 1080p HD is 1080 scan lines, non-interlaced



Interlaced



Non-Interlaced (progressive)

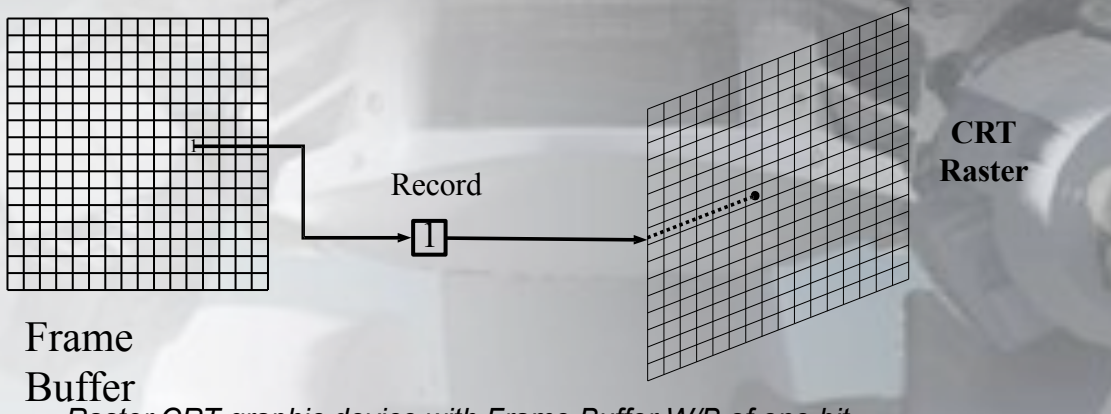
Interlacing

Odd Fields

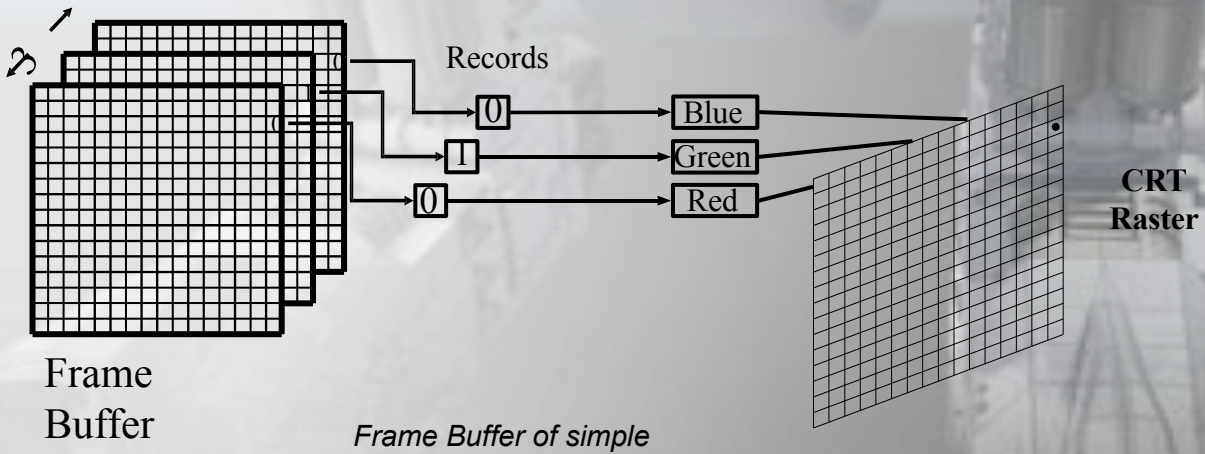
Even Fields

Problems with Interlacing

1.4 Characteristic devices: output



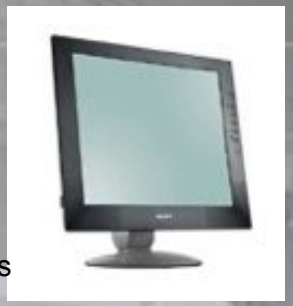
Raster CRT graphic device with Frame Buffer W/B of one bit plane

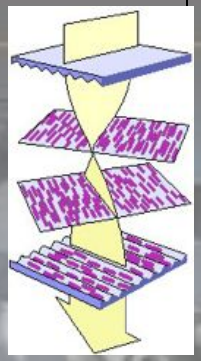


Frame Buffer of simple color

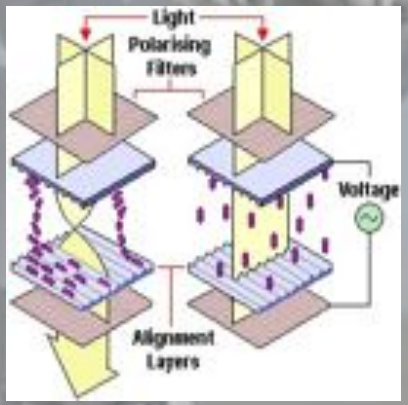
1.4 Characteristic devices: output

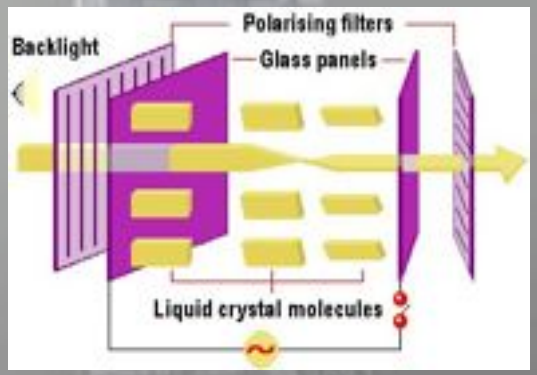
Liquid Crystal Displays (LCD)





- Liquid crystals are substances that have properties of liquid and solids
- When light goes through them, the LC forces it to follow the alignment of its molecules
- If an electric source is applied to them, its molecular alignment changes and, therefore, the way the light goes through them
- Displays are formed as LC panels (between two polarized filters) and a back light (normally a cold cathode)
- Most common technologies: DSTN (dual-scan twisted nematic) and TFT (thin film transistor)
- TFT: an extra matrix of transistors (1 per color, RGB, of each pixel) and allows better performance (avoiding ghosting), brightness and contrast
- Advantages over CRT: lower frame-rates (refreshment useful just for animation), less energy consumption, less space
- Disadvantages: fixed resolutions, less vision angles.

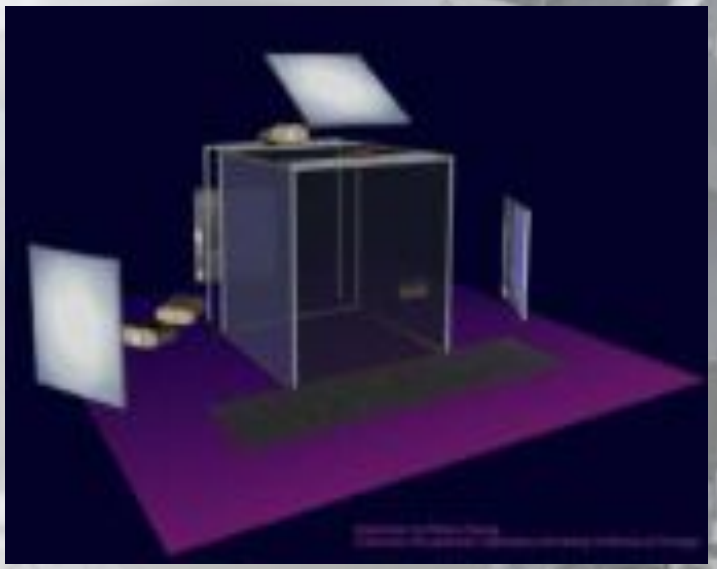




- **Other technologies**: plasma (high voltages to low pressure gases (xenon) that forces the gas to change from gas states to plasma generating light)

1.4 Characteristic devices: output

•Related with virtual reality and immersive environments: glasses and stereoscopic helmets, caves.



•Printing devices: printers and plotters.

1.4 Characteristic devices: input

- Keyboard, mouse
- Trackball, digital tablet, optical pen
- 3D digitizers, joysticks (2D and 3D)
- 3D gloves, motion capture systems
- Specific systems (flight and car driving simulators etc.)

2.5 Storage formats

Representation

- Vectors
- Bitmap

Definitions

- Bitmap representation
  - *Image is decomposed into pixels. The value of each one is saved individually.*
  - *It's easy to implement and works, with some limitations (e.g. aliasing), with any type of image*
- Vector based representation
  - *Image is represented by a set of geometrical shapes (lines, circles, curves etc.)*
  - *The parameters that define the geometric shapes are saved*

Applications

- Bitmaps: Complex color variations, like real photographs or images that are difficult to be vectorized.
- Vectors: Technical draws, CAD, imagery with simple shapes and coloring.

1.4 Characteristic devices: output

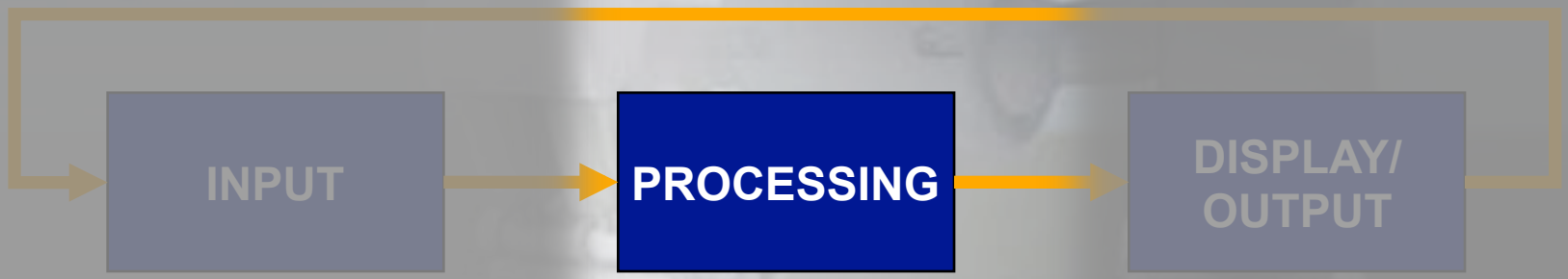
- Vector terminals

- Raster terminals
  - Screen composed by pixels
  - The ray traverses the screen from left to right and from top to bottom, lighting the pixels up
  - Images is saved in memory (frame-buffer)
  - The frame-buffer and the screen pixels are traversed simultaneously converting the color digital codes into ray intensities
  - Considerations
    - *Resolution ⇔ Sizes in pixels*
    - *Aliasing*
    - *Constant frame-rate*
    - *Color possibility (n bits per pixel => 2^n colors)*
    - *Differences between color modes of high density (16bits/pixel) and true color (24bits/pixel) and palette modes*

2.5 Storage formats

	BITMAPS	VECTORS
Advantages	•Any type of image can be saved •Programming is generally simpler	•More efficient and flexible in many applications •Parts of a scene can be manipulated •Scale changes do not affect to resolution and quality
Disadvantages	•Lot of memory required •Huge volume of data •Few flexibility •Fixed resolution	•There are limits or important difficulties in order to represent some images

Interactive Computer Graphics

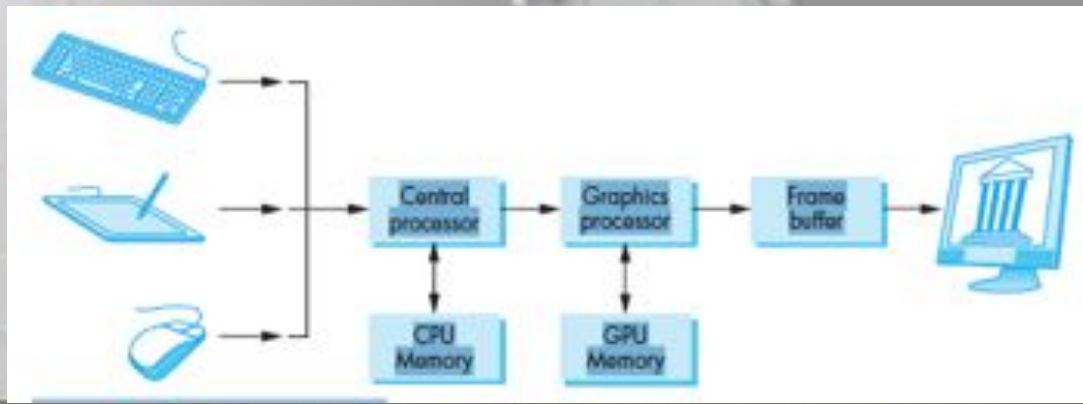


Mouse
Tablet and stylus
Force feedback device
Scanner
Live video streams

Screen
Paper-based printer
Video recorder
Projector
VR/AR headset

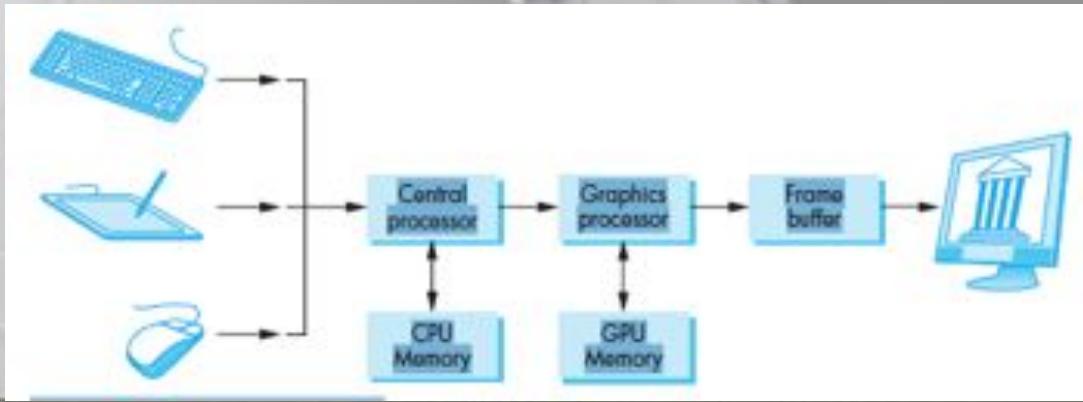
High-level view of a graphics system

1. Input devices
2. Central Processing Unit
3. Graphics Processing Unit
4. Memory
5. Frame buffer
6. Output devices



CPU and GPU

- simple system may be only one processor, the central processing unit (CPU) of the system
- both the normal processing and the graphical processing
- main graphical function of the processor is to take specifications graphical primitives (such as lines, circles, and polygons) generated by application programs and to assign values to the pixels in the frame buffer that best represent these entities



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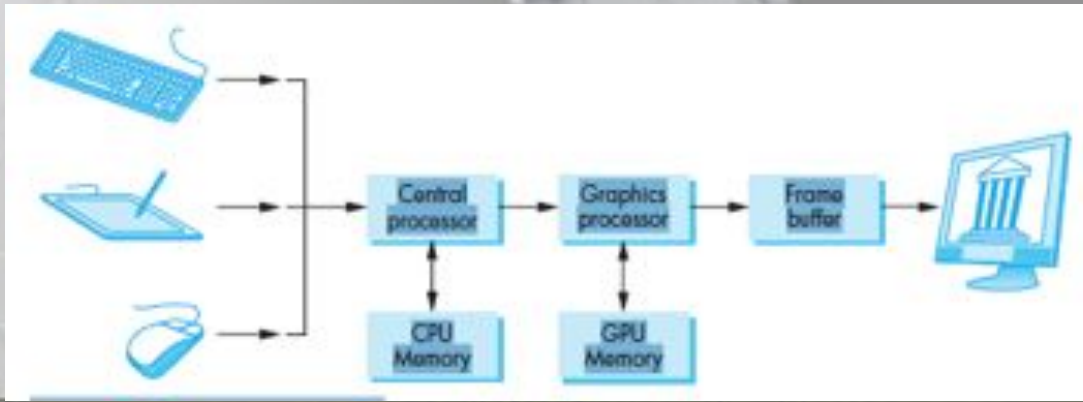
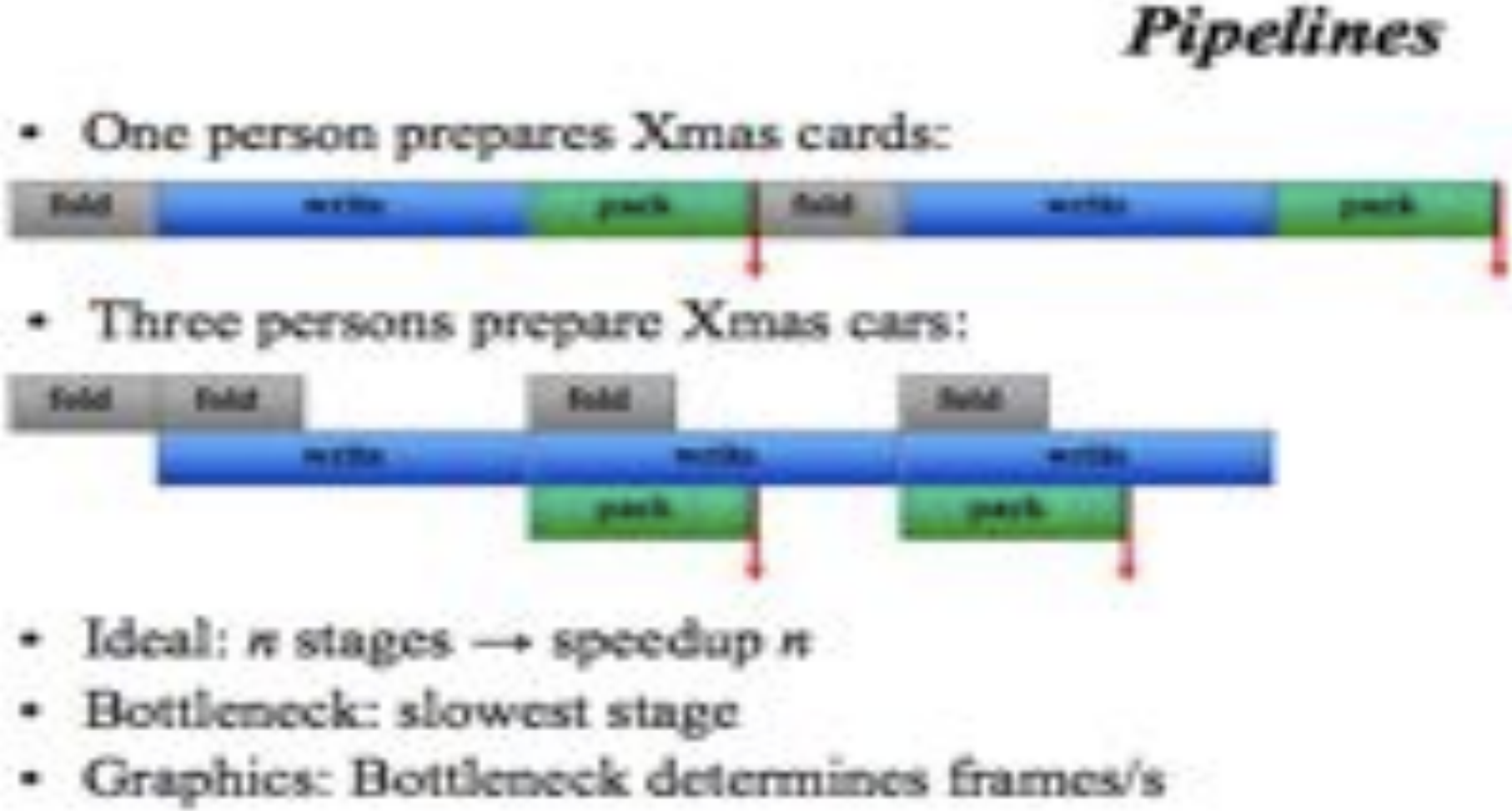


Graphics pipeline

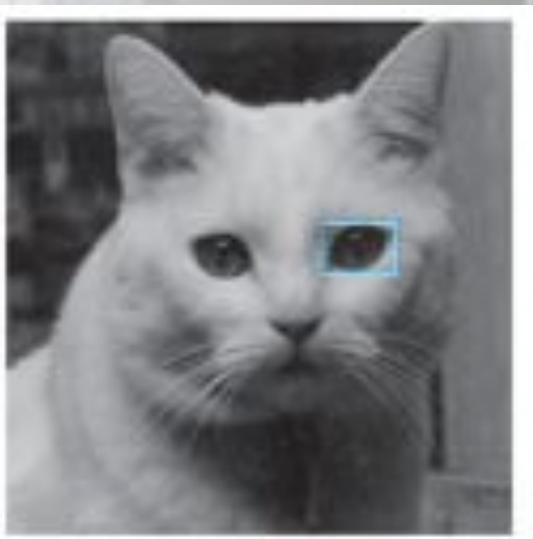


Graphics pipeline

- Most important use of custom VLSI circuits has been in creating pipeline architectures.
- In our pipeline, there is an adder and a multiplier
- If we use this configuration to compute a + (b _ c), the calculation takes one multiplication and one addition-the same amount of work required if we use a single processor to carry out both operations
- suppose that we have to carry out the same computation with many values of a, b, and c
- Now, the multiplier can pass on the results of its calculation to the adder and can start its next multiplication while the adder carries out the second step of the calculation on the first set of data

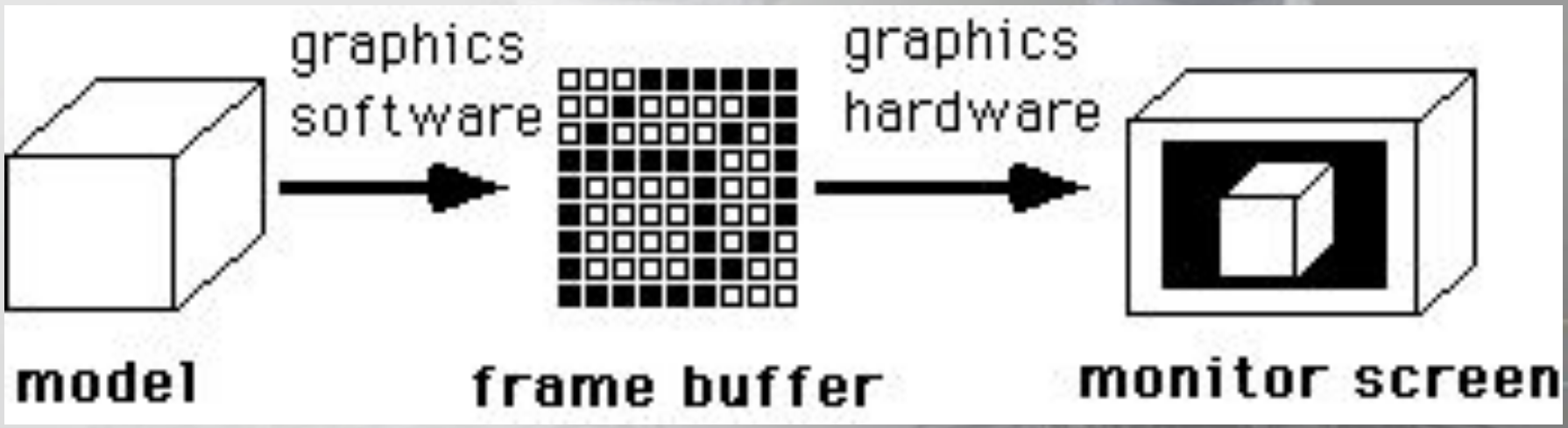
Pixels and the Frame Buffer

- Virtually all modern graphics systems are raster based
- The image we see on the output device is an array—the raster—of picture elements, or pixels, produced by the graphics system
- each pixel corresponds to a location, or small area, in the image. Collectively, the pixels are stored in a part of memory called the frame buffer
- The frame buffer can be viewed as the core element of a graphics system



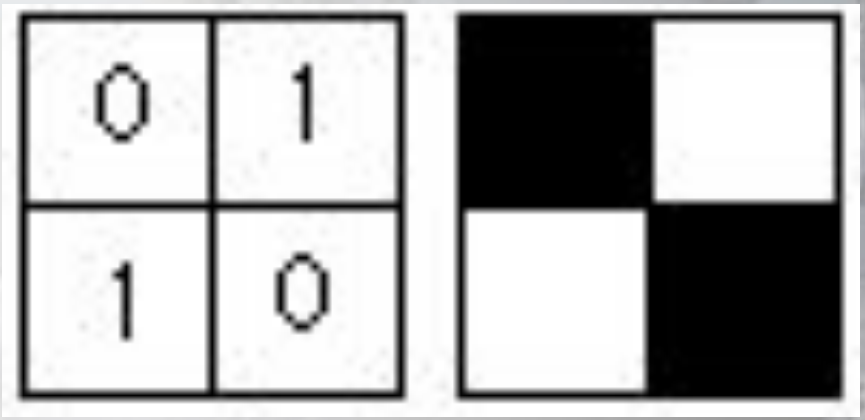
Pixels and the Frame Buffer

- Frame buffer - array of computer memory used to store an image to be displayed
- The user manipulates the values in the frame buffer.
  60 times a second (or at some other fixed rate) the frame buffer is copied onto the display device.
- If video screen is 1920 pixels wide by1080 pixels tall the frame buffer must be able to store 1920 X by 1080 elements ... one element for each pixel on the screen



monochrome display

- 1920 X 1080 x 1bit (bit is either 0=off, or 1=on.)
- Each of the 1920 X 1080 pixels can be either on or off (white or black)
- 2,073,600 bytes total



8 bit greyscale display

- 1920 X 1080 x 8bit (each pixel is 8 bits deep so values 0-255 are possible.)
- Each of the 1920 X 1080 pixels can be one of 256 shades of grey (from black to white.)
-

0	150
255	50