

CS535

Intermediate Computer Graphics

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1. Introduction

1.1 Graphics Areas

- **Modeling:** building specification of shape and appearance properties that can be stored on the computer
- **Rendering:** creation of shaded images from 3D computer models
- **Animation:** to create an illusion of motion through sequences of images

Advantages

- **quantitative description** - precise, not easy to be recognized
- **Pictorial description** - easy to be recognized

History

Founded by the PhD thesis of Ivan D. Sutherland at MIT in 1963,

- A **line drawing system** with **data structures** for storing symbol hierarchies and **interaction techniques**

SIGGRAPH: important CG organization, formed in 1969

Website: *<http://www.siggraph.org>*

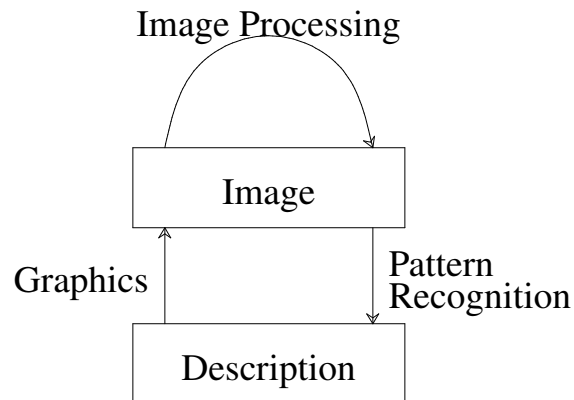
1.2 Applications

Art, Entertainment, and Publishing

- Movie production, Animation, and Special Effects
- Computer Games
- Browsing on the World Wide Web
- Slide, Book and Magazine Design

Computer Graphics and Image Processing

Blending together more each year



Process Control (Monitoring)

Status display for refineries, power plants, computer networks from sensors attached to critical components

Simulation

- Flight simulation
- Simulation of the movement of a robot
- Simulation of 'virtual world'

Computer Aided Design (CAD)

- Computer Aided Mechanical Part Design (big market)
- Computer Aided Architectural Design
- Electrical Circuit (IC) Design

Scientific Analysis and Visualization

Assist scientists in understanding measured data

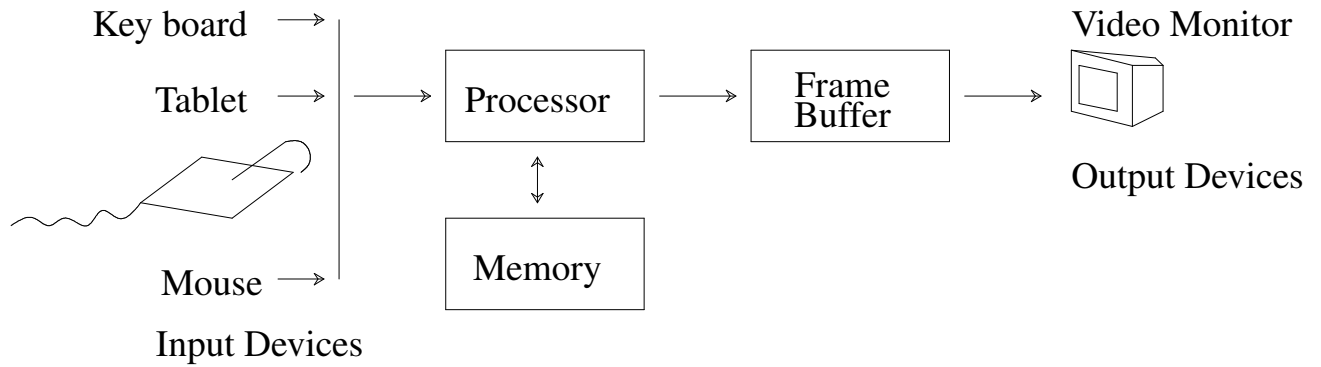
Provide insight into complex mathematical ideas

1.3 Elements of Pictures Created in Computer Graphics

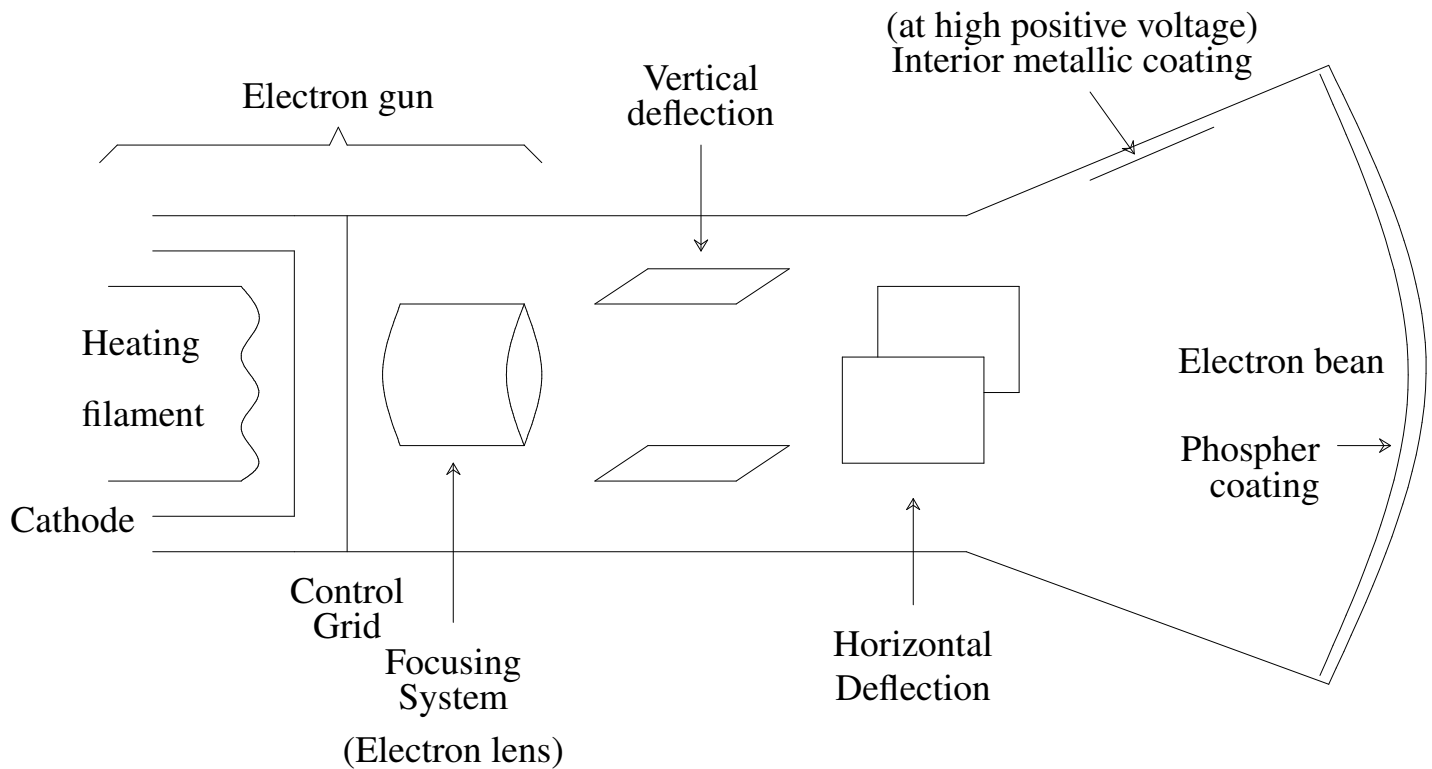
Output Primitive:

- polylines
- text
- filled regions
- raster images

1.4 A Graphics System



Video Monitor:

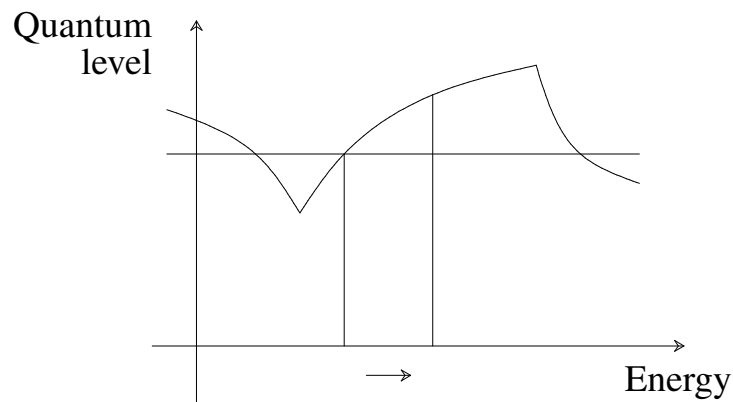


Control-grid voltage: control the picture's intensity

Focusing system: force the electrons to converge

Deflection systems: to trace a picture on screen (most crucial part of the monitor)

Phosphor: when struck by electron beams, most of the kinetic energy carried by the electrons is transferred to the electrons of the phosphor atoms, so the electrons of the phosphor atoms jump to a higher quantum energy levels. These excited electrons return to their previous quantum levels by giving up their extra energy in the form of light at frequency depicted by the quantum theory



Persistence: the time from the removal of excitation to the moment when phosphorescence decayed to 10% of the initial light output

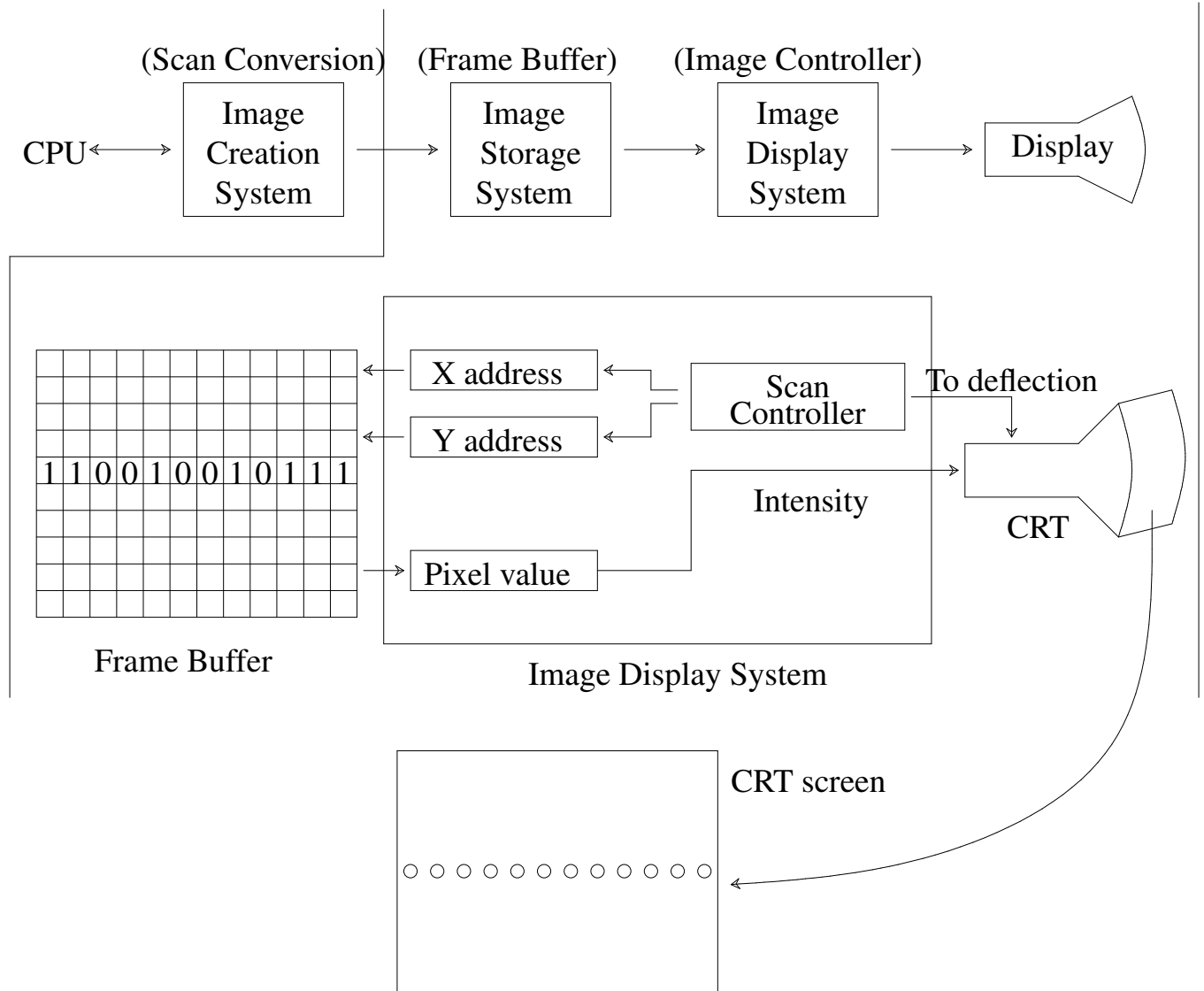
Refresh rate: number of times per second a picture is redrawn (determined by persistence)

Fusion frequency: the refresh rate above which a picture stops flickering and fuses into a steady picture

Note:

1. Refresh rate for raster scan display is fixed (30 to 60), independent of the picture complexity
2. Highly dynamic applications need low-persistence phosphor. CAD applications tend to use long-persistence phosphor.
3. The relationship between fusion frequency and persistence is nonlinear.

1.5 Display processing Unit:



A simple two-color raster-scan system

Image Storage System (frame buffer, bitmap):

- refresh memory arranged as a 2D array; each entry corresponds to a screen pixel
- each entry is composed of a number of bits; brightness and/or color value of each pixel of the screen is stored in corresponding entry in frame buffer
- implemented with solid state RAM

Image Display System (video/image controller):

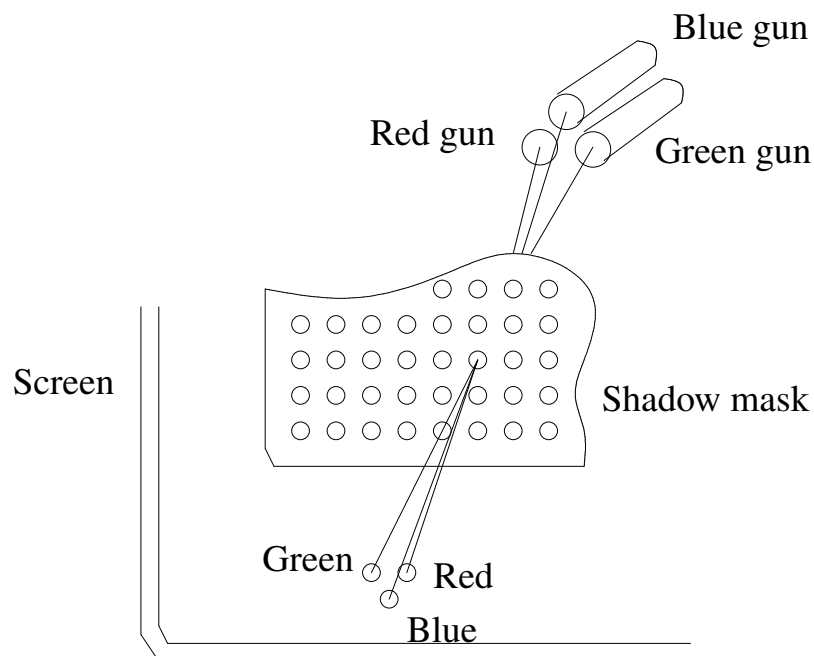
- cycle through frame buffer row by row, 30 or 60 times/sec
- memory reference addresses are generated in synchronism with the raster scan; contents of the memory are used to control monitor beam's intensity
- changes in frame buffer is done during the 1.3 millisecond flyback (or, vertical retrace) time
- interlaced raster scan (to produce a picture whose effective refresh rate is closer to 60 than to 30 Hz.

Image Creation System:

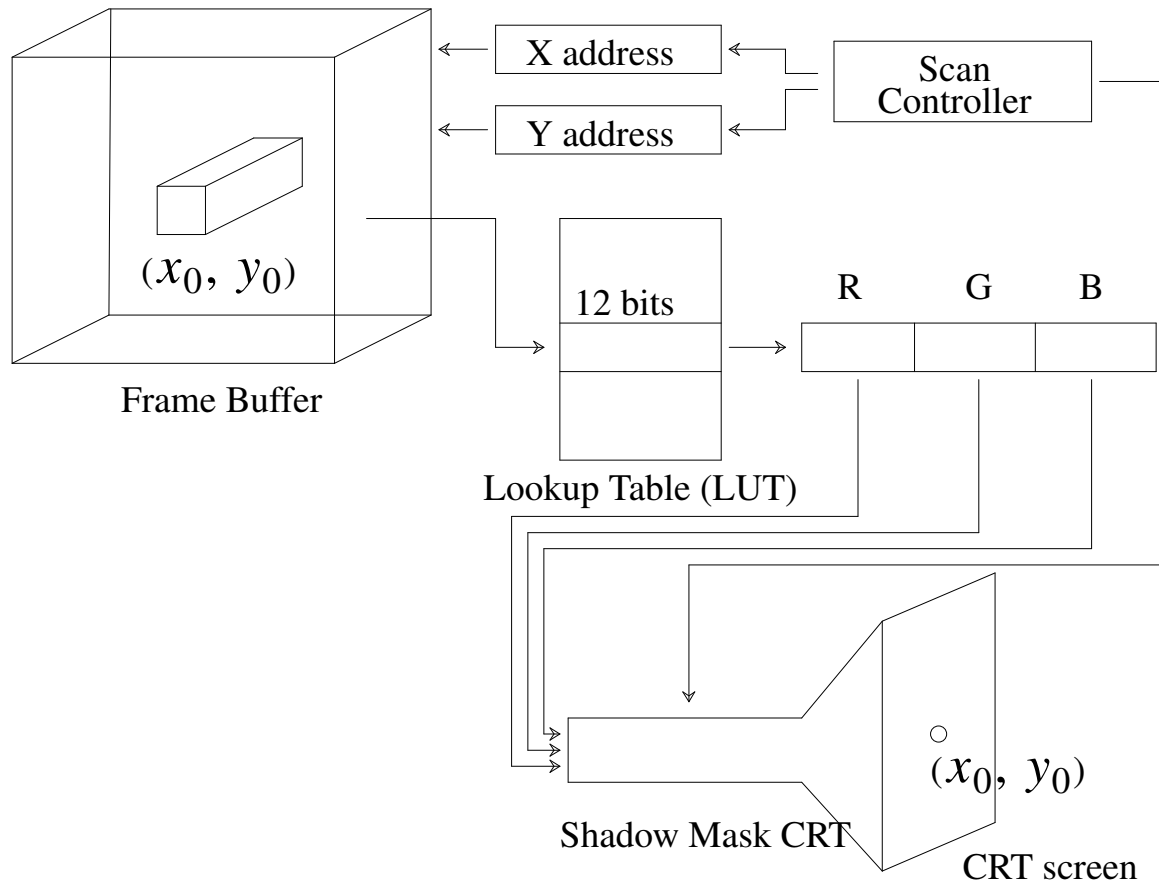
- scan convert abstract representation of an image into appropriate pixel values in the frame buffer

1.6 Shadow Mask Color Monitor

- phosphor dots (red, green, blue) are arranged in triangular pattern called triad (or, pixel)
- three electron guns are used
- a shadow mask, behind the view surface, is equipped so that each small hole for each triad (holes are aligned so that each electron gun excites its corresponding phosphor dot)
- resolution of these monitors is limited
(high resolution: triads are on about .21mm centers)
(home TV: triads are on about .60mm centers)



1.7 Display with Lookup Table (LUT)

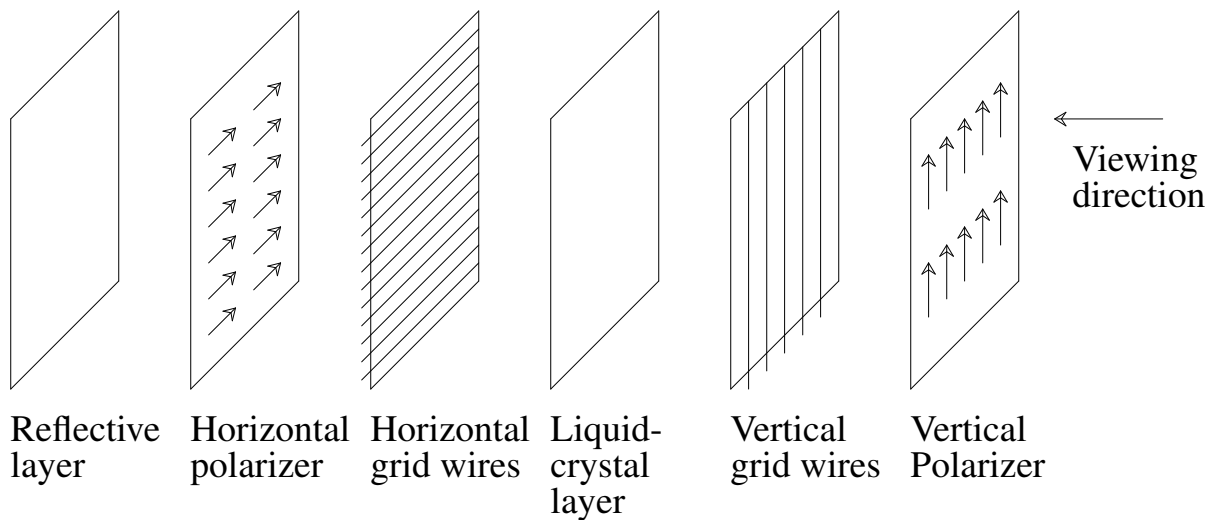


- each number stored in frame buffer is an index (address) into a lookup table (color table or color map)
- Lookup table provides significant saving on memory while gives the ability to change colors from picture to picture

1.8 Flat-Panel Displays

- **Liquid-crystal display (LCD)**
- **Active matrix panel (AMP)**
- **Plasma panel**

Liquid-crystal display (LCD):



- Six layers (see the above figure)
- Liquid-crystal is made up of long crystalline molecules arranged in a spiral fashion
- Direction of polarization of polarized light passing through is rotated 90°
- The crystals line up in the same direction when in an electric field, therefore no polarizing effect

- In this case the light passing through the liquid-crystal layer will be absorbed by the rear polarizer, so the viewer sees a dark spot on the display
- To create a dark spot at (x_1, y_1) , use *matrix addressing*: applying a negative voltage $-V$ to the vertical grid wire x_1 and a positive voltage $+V$ to the horizontal grid wire y_1 to create an electric field at (x_1, y_1) .
- To display dots at (x_1, y_1) and (x_2, y_2) , cannot simply apply negative voltage to x_1 and x_2 and positive voltage to y_1 and y_2 : that would cause dots to appear at (x_1, y_1) , (x_2, y_2) , (x_3, y_3) and (x_4, y_4) . We have to activate them one at a time. The display is refreshed one row at a time.

Active Matrix Panel:

- LCD panel with a transistor at each grid point
- Transistor can hold the cell in "adjusted" state until changed
- The display need not be refreshed and is brighter

Plasma Panel:

- Similar to the center part of the previous figure
- Array of tiny neon bulbs
- Need not be refreshed

1.9 Input Devices

1.9.1 Logical Classes of devices and techniques

Logical Device	Function	Prototype (Physical device)
Keyboard (string)	Input a character string	alphanumeric keyboard
Locator	Indicate a position and/or orientation	Tablet, mouse, joystick
Pick	Select a displayed entity	Light pen
Choice	Select from a set of actions or choices	PFK, mouse
Dial (Valuator)	Input an analog value (number)	Slidebar, potentiometer

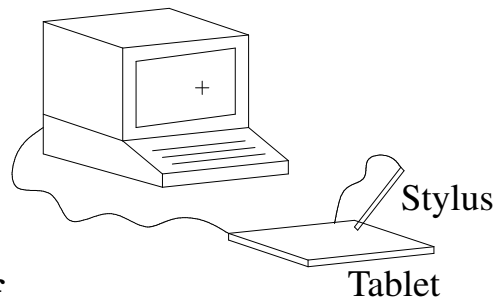
1.9.2 Physical Input Devices

Keyboard:

- each keystroke causes a 7-bit code (ASCII, EBCDIC, etc) to be stored in a character register, the CPU is interrupted
- the interpretation of the code is determined by the CPU program
- characters might be accumulated into a buffer until a terminating character is typed, there-by give the application program a character string input device

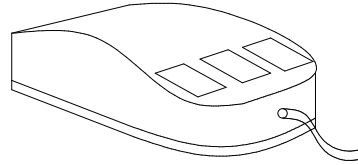
Tablet:

- A flat surface and a stylus or hand cursor
- electrical sensing mechanism is used to measure the stylus or cursor position (within half inch of the tablet surface)
- downward pressure on the stylus closes a microswitch (pressure-sensitive switch) and interrupts the computer
- particular handy for digitizing drawings



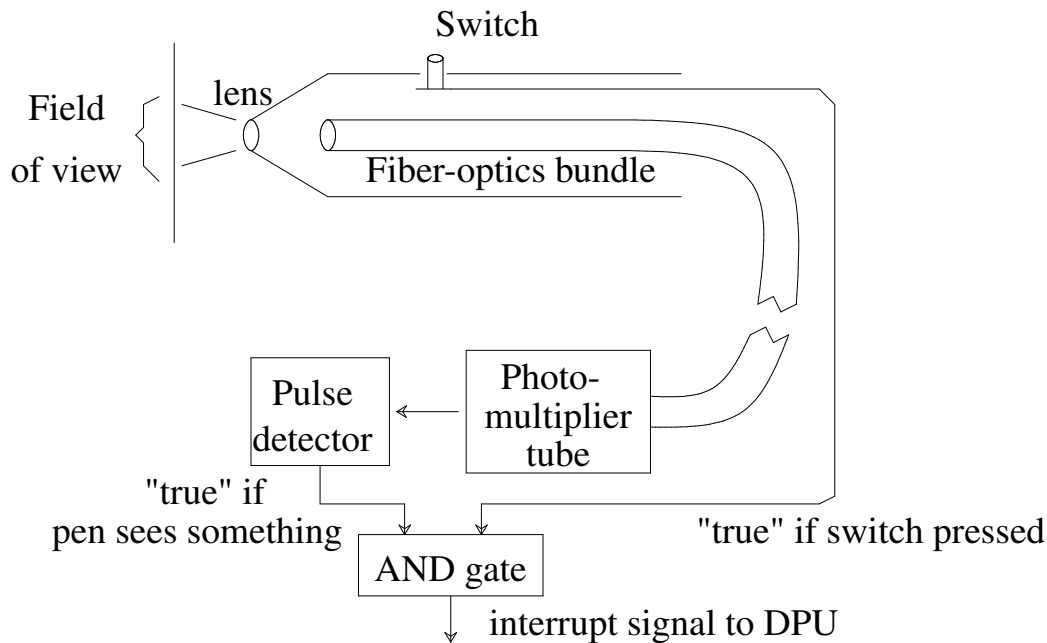
Mouse : --- most commonly used

- using mechanical detector or optical detector to measure motion



- mechanical mice measure distance by turning a ball (at the bottom) and consequently a pair of encoders. The encoders measure motion in two directions.
- optical mice measure distance traveled by counting lines on a special pad
- a relative device, has no absolute origin, report only changes from their former position
- can be used to specify an arbitrarily large change in position
- the application program can reposition the cursor anywhere on the screen

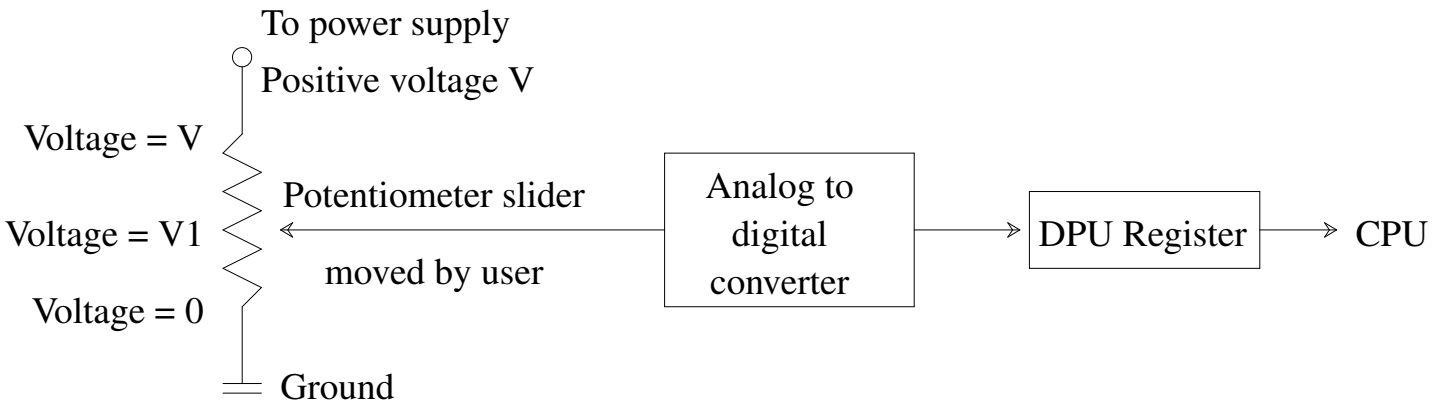
Light pen :



- the pen sees the sharp burst of fluorescent light emitted when the electron beam is actually bombarding the phosphor, not sensitive to the more prolonged phosphorescence or to ambient room light
- pen's output connected to image display system (IDS); when IDS is interrupted, it sends CPU the contents of the X and Y registers which are the x and y coordinates of the pixel detected (hence, on a raster-scan display, light pen implements a locator)
- popularity of light pens will decrease in the future

Valuator : (prototype: potentiometer)

- can be rotary or slide potentiometers (slide bars)
(e.g., valume, balance, and tone controls on a stereo set)



- by rotating the dial (for rotary potentiometer) or moving the slider (for slide potentiometer), scalar can be generated and placed in DPU device registers and then read by CPU

1.10 Input Modes

- Defined by the relationship between the measure process and the trigger

Measure: what the device returns to the user program

Trigger: a physical input on the device

- The display processing unit contains a number of registers (buffers). Once initialized, input devices store appropriate values in these registers

Request mode: The measure of the device is not returned until the device is triggered

Sample mode: Input provides immediate input
No trigger is needed

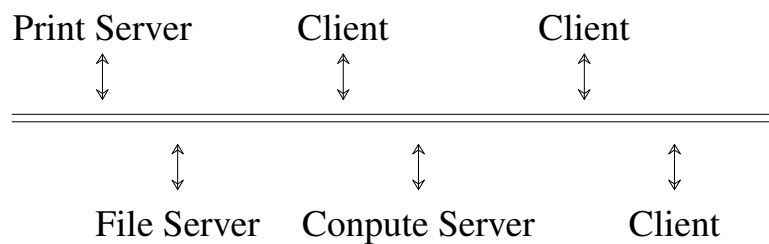
Event mode: when a device is triggered, the device measure with the identifier for the device is placed in an "event queue"
(but application program is not interrupted)

1.11 Clients and Servers

Primary motivation for the development of X Window System:

"do graphics over a network"

In a world of distributed computing and networks, building blocks are entities called *"server"*



Server: remote machine supporting client workstations

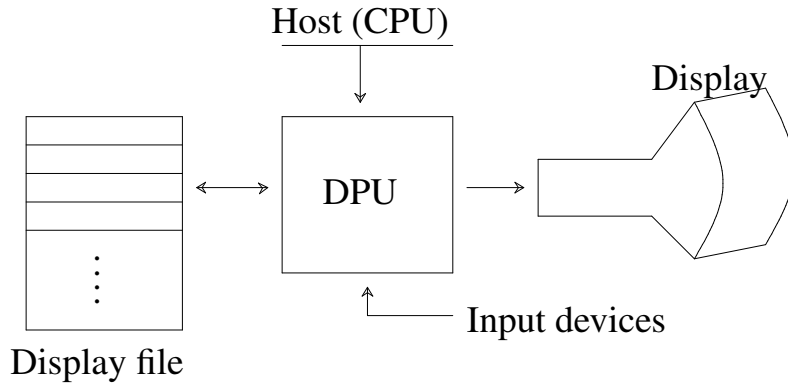
However, for X Window System

Server: device that displays the graphics
(machine in front of the user)

Client: device that does computation
(whatever machine running the application)

Concept of X Server

Then (Vector Display Device):



Now

