Hochiminh city University of Technology
Faculty of Computer Science and Engineering

COMPUTER GRAPHICS

CHAPTER 01:

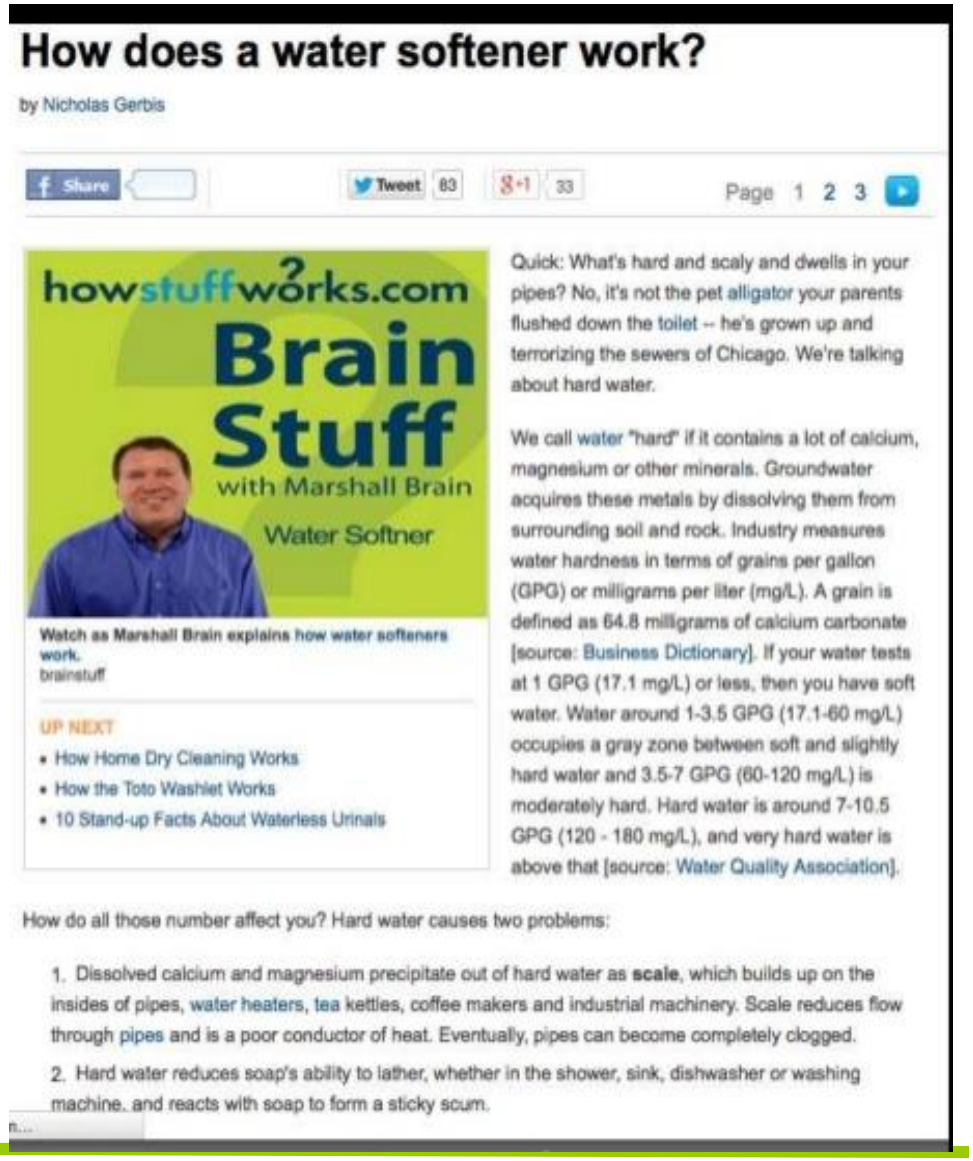
Graphics System

Outline

- Computer Graphics: Why & What?
- Application
- Computer Graphics Systems
- Image & Image Formation
- Camera
- Models and Architectures
- API Contents

Computer Graphics: Why & What?

- Why
  - "*A Picture is Worth a Thousand Words*"



How does a water softener work?

by Nicholas Gerbis

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howstuffworks.com Brain Stuff with Marshall Brain

Water Softner

Watch as Marshall Brain explains how water softeners work.
brainstuff

UP NEXT
- How Home Dry Cleaning Works
- How the Toto Washlet Works
- 10 Stand-up Facts About Waterless Urinals

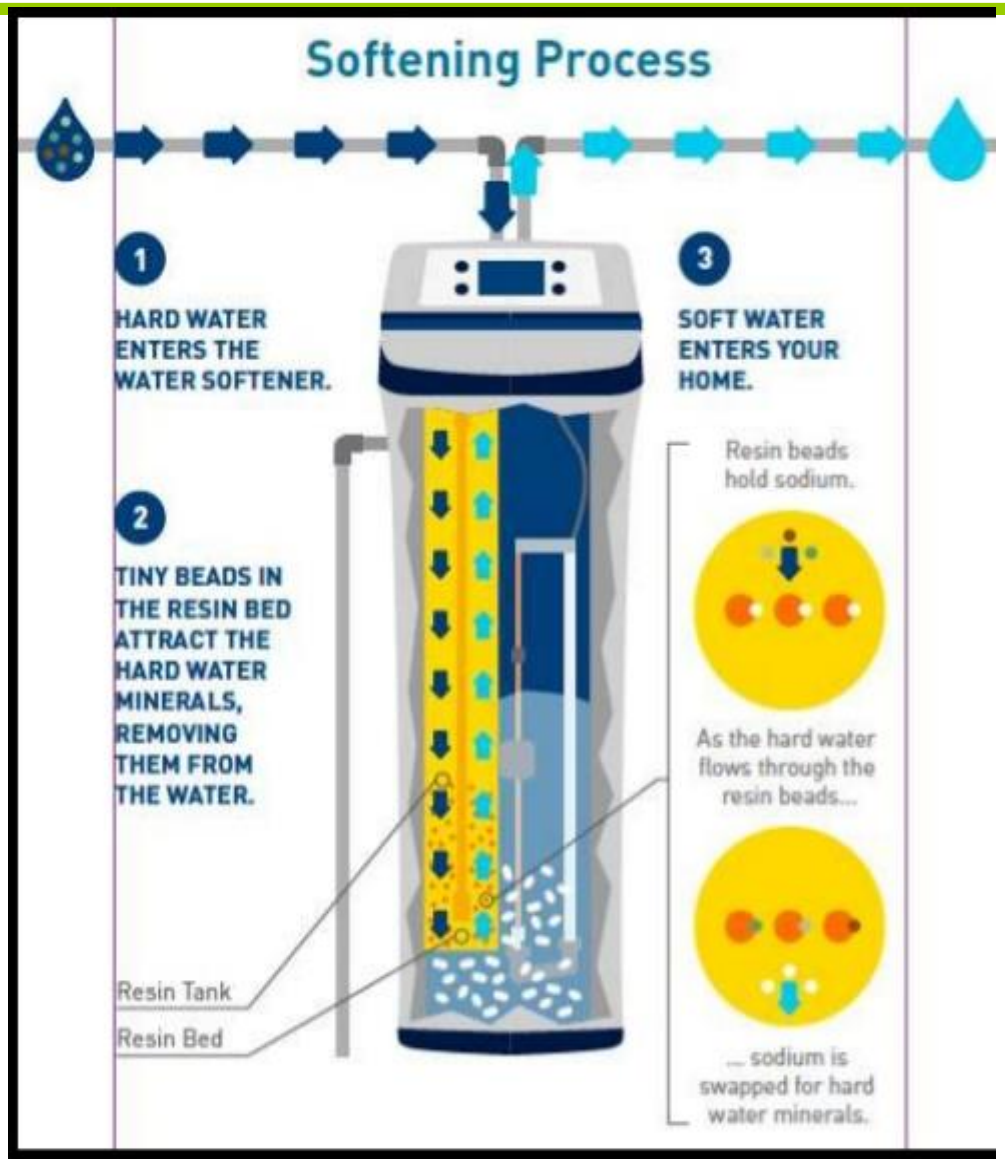
Quick: What's hard and scaly and dwells in your pipes? No, it's not the pet alligator your parents flushed down the toilet -- he's grown up and terrorizing the sewers of Chicago. We're talking about hard water.

We call water "hard" if it contains a lot of calcium, magnesium or other minerals. Groundwater acquires these metals by dissolving them from surrounding soil and rock. Industry measures water hardness in terms of grains per gallon (GPG) or milligrams per liter (mg/L). A grain is defined as 64.8 milligrams of calcium carbonate [source: Business Dictionary]. If your water tests at 1 GPG (17.1 mg/L) or less, then you have soft water. Water around 1-3.5 GPG (17.1-60 mg/L) occupies a gray zone between soft and slightly hard water and 3.5-7 GPG (60-120 mg/L) is moderately hard. Hard water is around 7-10.5 GPG (120 - 180 mg/L), and very hard water is above that [source: Water Quality Association].

How do all those number affect you? Hard water causes two problems:

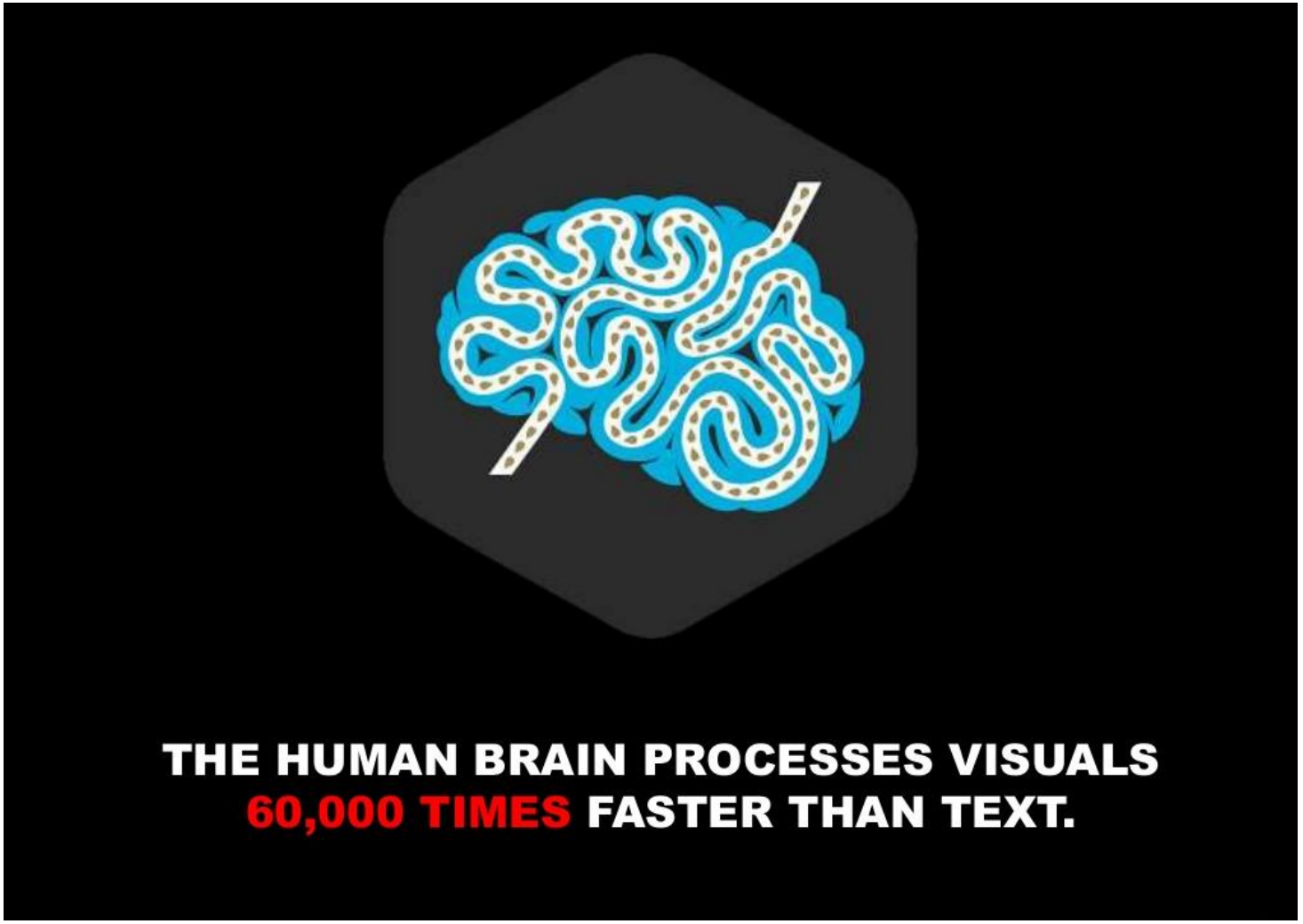
1. Dissolved calcium and magnesium precipitate out of hard water as **scale**, which builds up on the insides of pipes, water heaters, tea kettles, coffee makers and industrial machinery. Scale reduces flow through pipes and is a poor conductor of heat. Eventually, pipes can become completely clogged.
2. Hard water reduces soap's ability to lather, whether in the shower, sink, dishwasher or washing machine, and reacts with soap to form a sticky scum.

Computer Graphics: Why & What?



Computer Graphics: Why & What?

Computer Graphics: Why & What?



Computer Graphics: Why & What?

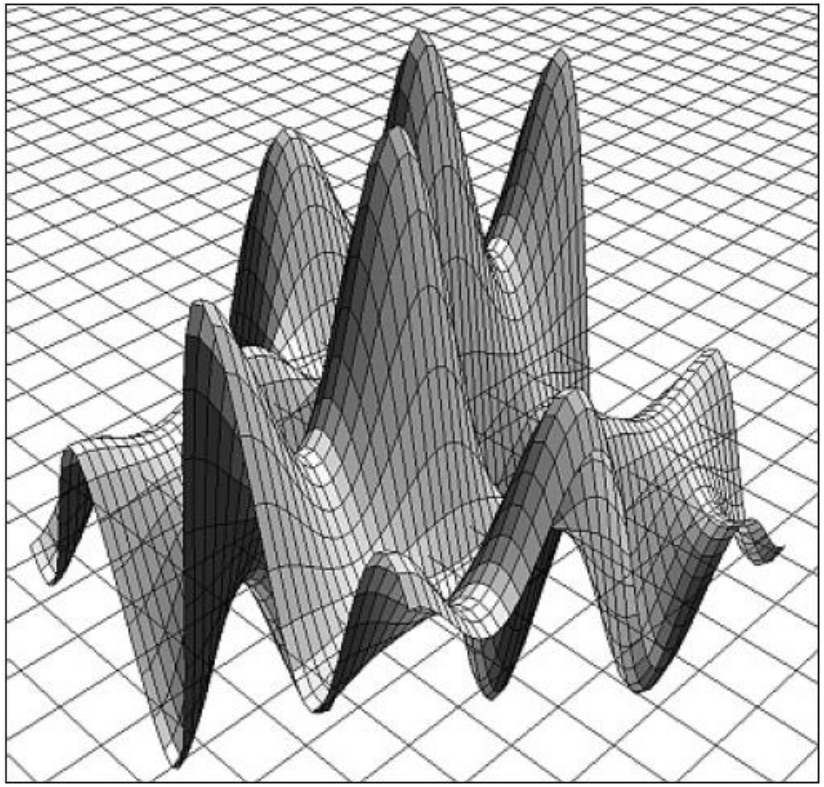
- What
  - *Computer graphics* deals with all aspects of creating images with a computer
  - **Hardware**
  - **Software**
    - High-Level: Maya, Lightwave
    - Low-level: OpenGL, Direct3D – Libraries for
    - programming graphics applications
  - **Applications**

Application

- Display of Information
- Computer-Aided Design
- Simulation and Animation
- User Interface

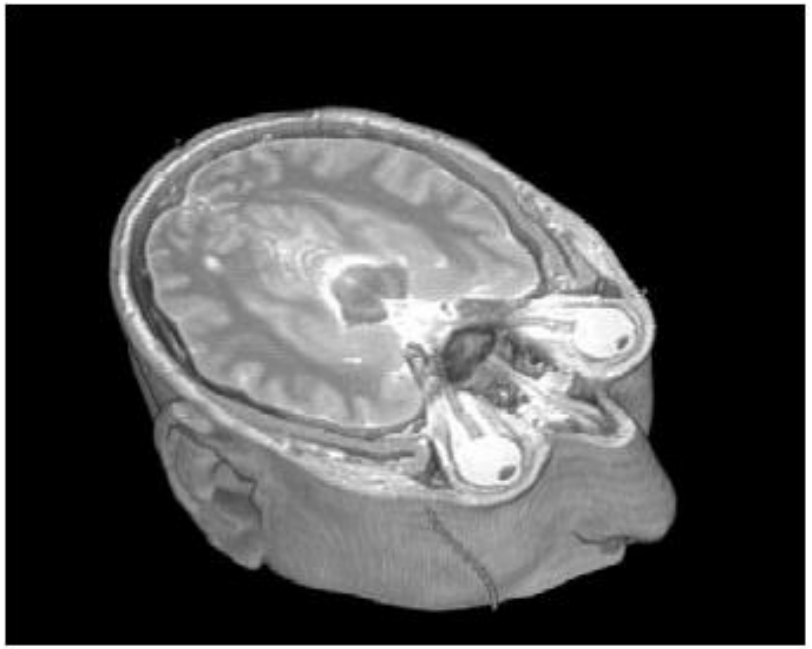
Application

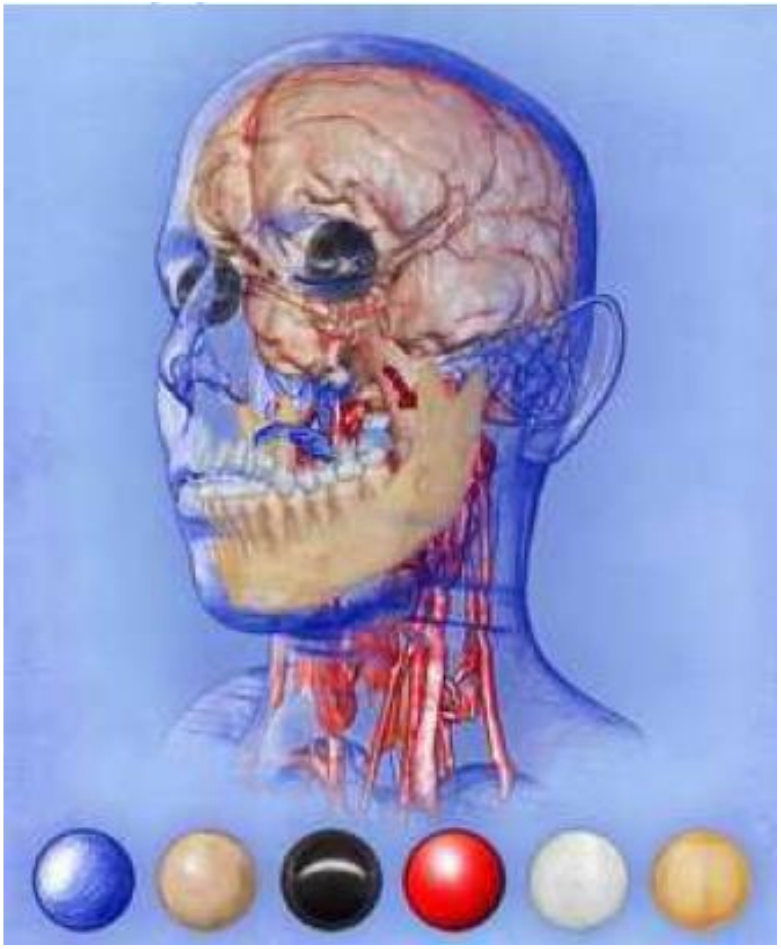
- Display of Information
  - Complex scientific data



Application

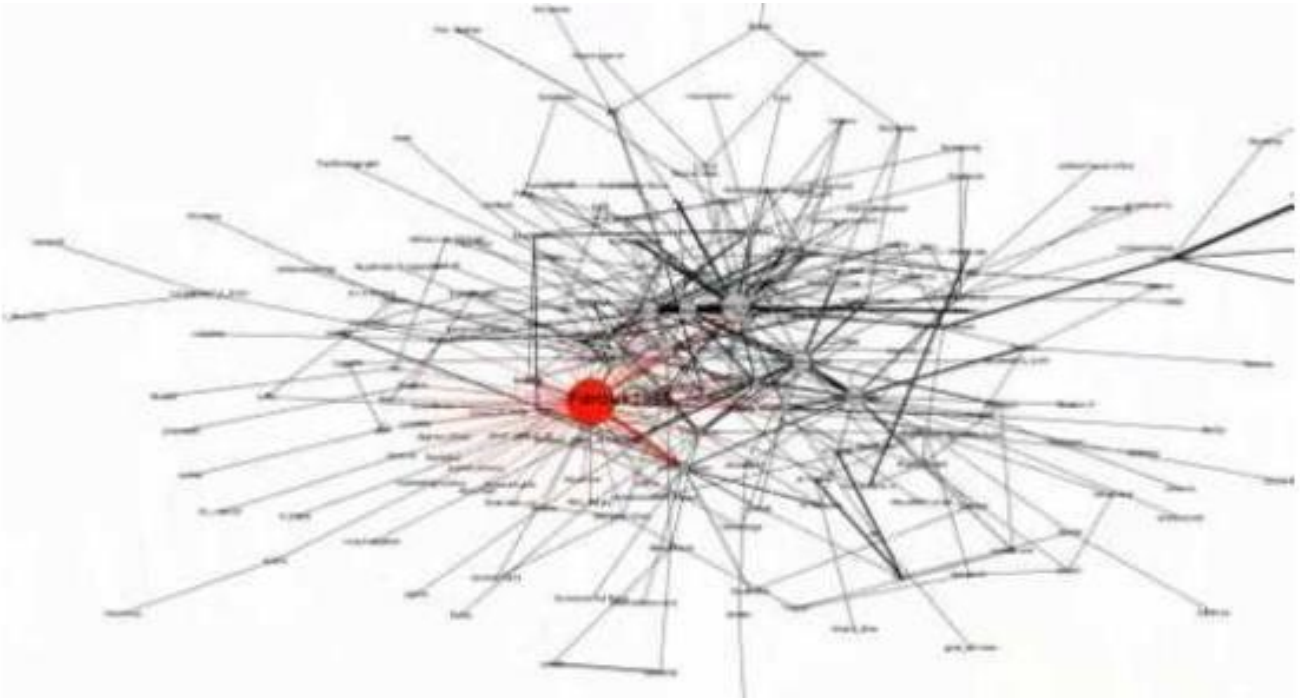
- Display of Information
  - **Medical Imaging**





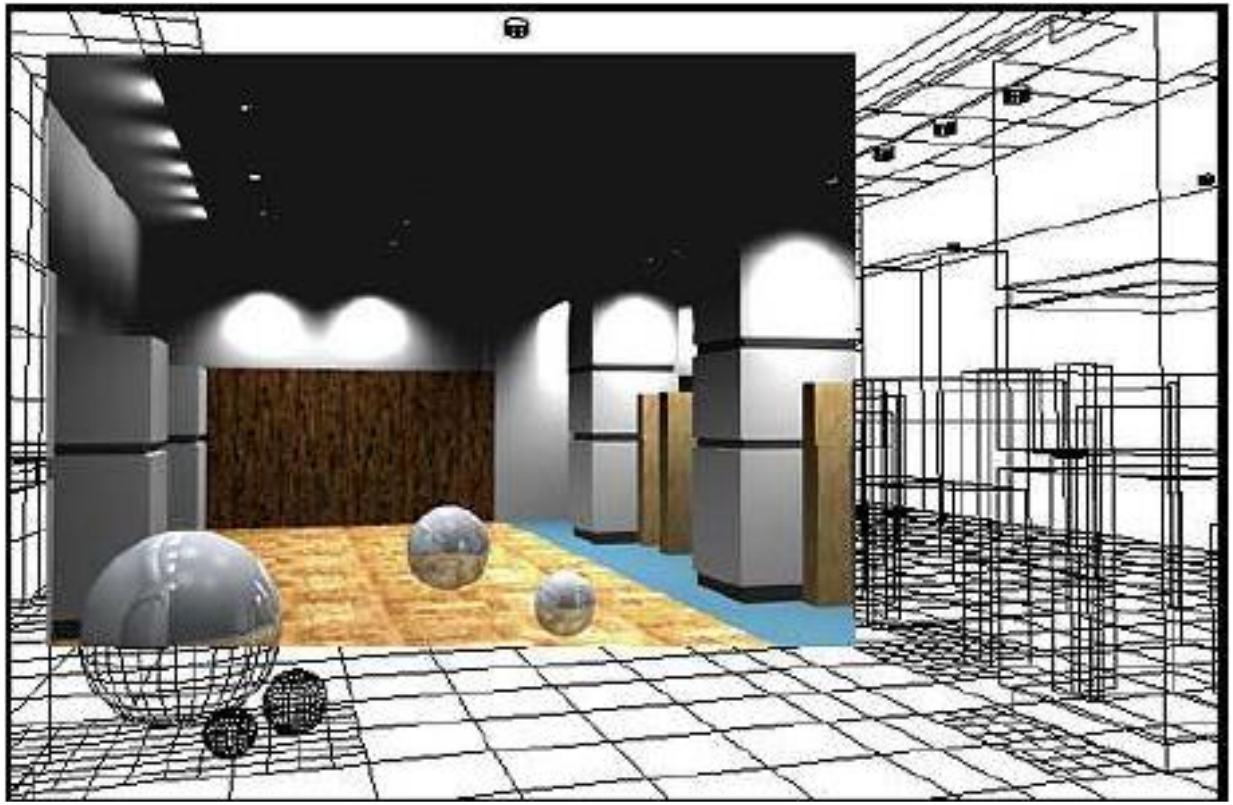
Application

- Display of Information
  - **Network and threat visualization**



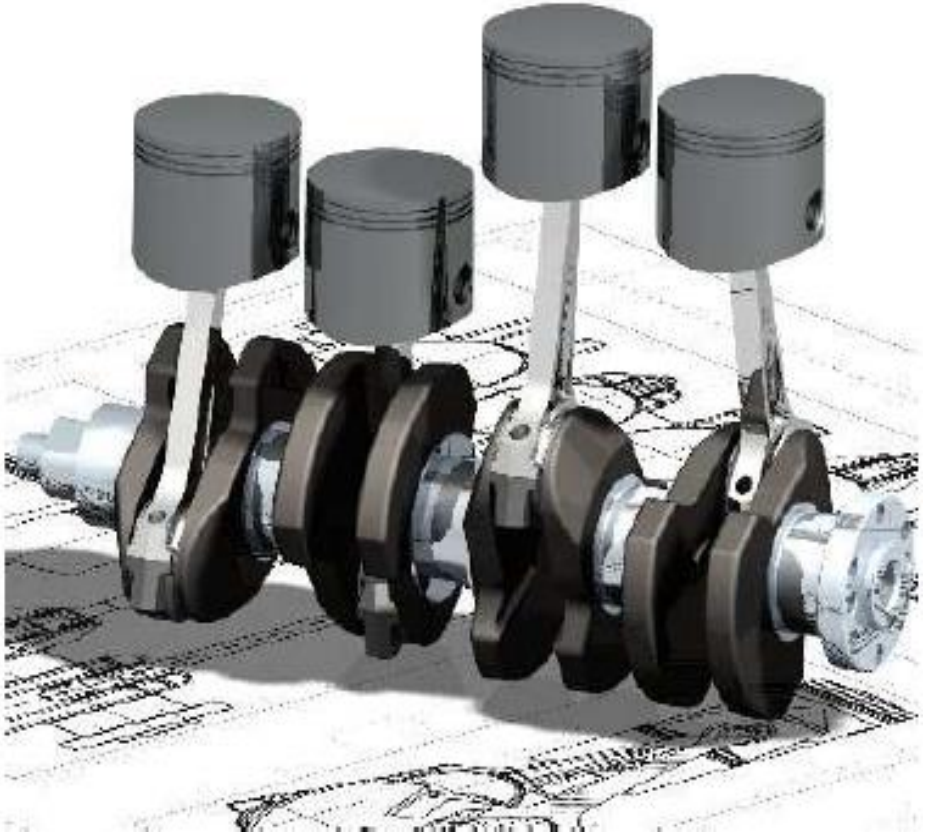
Application

- Computer-Aided Design
  - **Architecture**



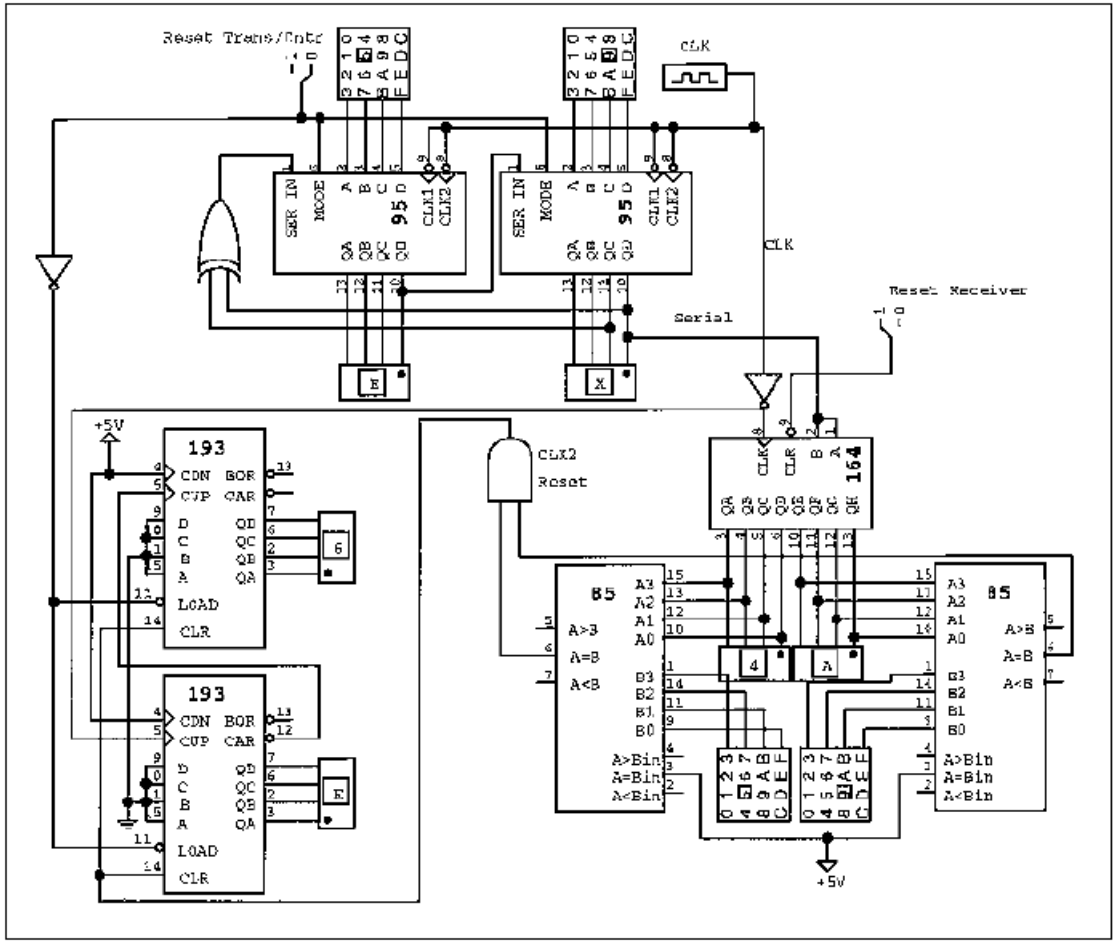
Application

- Computer-Aided Design
  - **Mechanical Engineering**



Application

- Computer-Aided Design
  - Digital Logic Design



Application

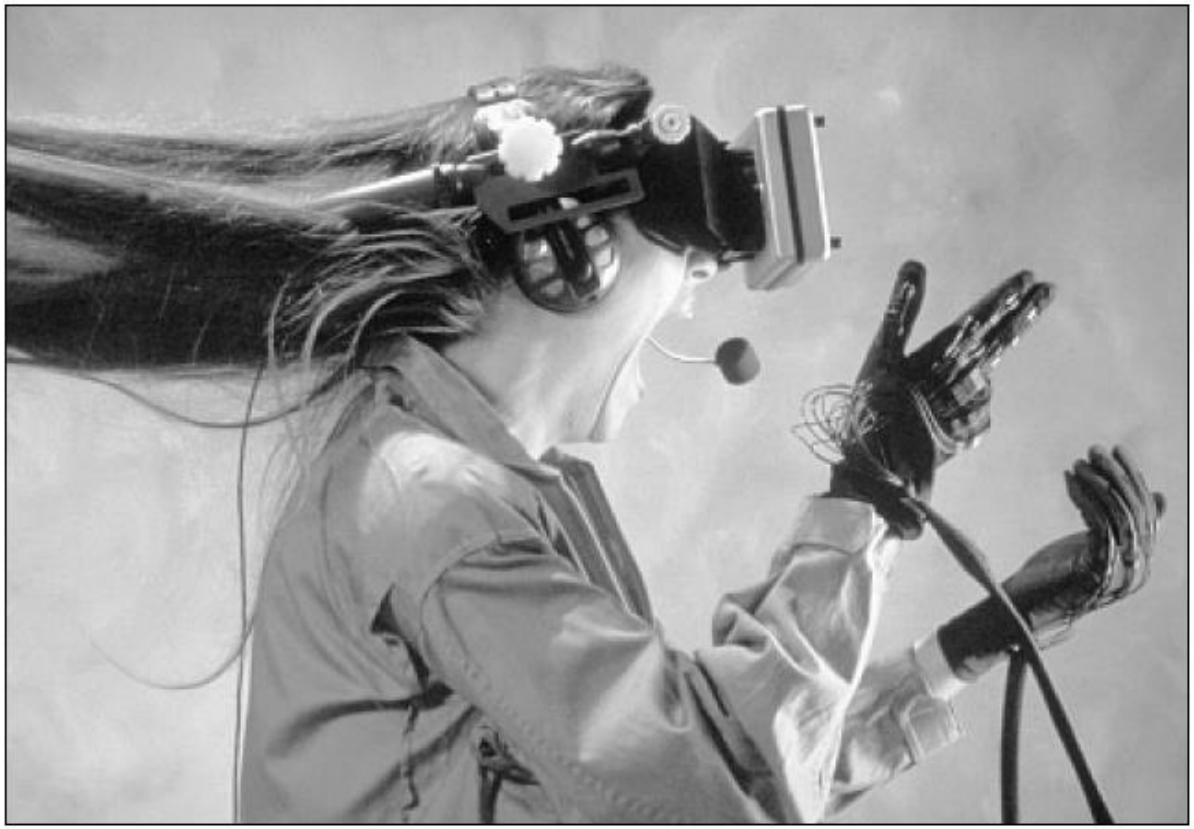
- Simulation and Animation
  - **Flight simulators**

Application

- Simulation and Animation
  - **Surgical training**

Application

- Simulation and Animation
  - Virtual Reality



Application

- Simulation and Animation
  - **Entertainment**

Application

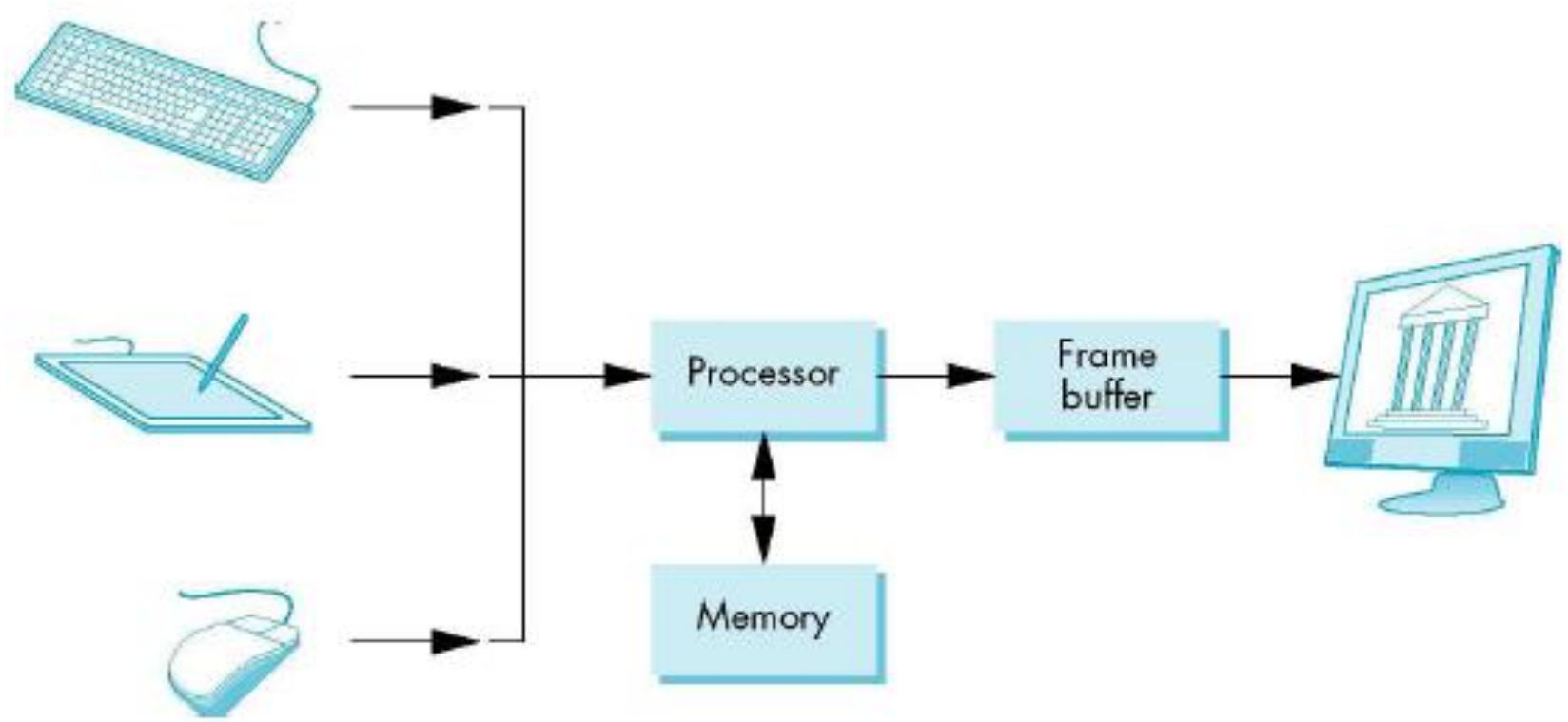
User Interface

Computer Graphics Systems

- System's Overview
  - Input devices
  - Processor
  - Memory
  - Frame buffer
  - Output devices

Computer Graphics Systems

- System's Overview



Computer Graphics Systems

- Input devices
  - **Keyboard, Button boxes, dials**
  - **Mouse Devices: 2D and 3D**
  - **Trackballs and Spaceballs**
  - **Joysticks**
  - **Data Gloves, CyberGloves**
  - **Data tablet**
  - **Image Scanner**
  - **Touch Panels**
  - **Light Pens**
  - **3D Scanner**

Computer Graphics Systems

- Frame buffer
  - **Raster-based systems:**
    - The output picture is produced as an array – the raster – of picture elements, or pixels
    - Almost all graphics systems are raster based.
  - **Vector-based systems:**
    - The output picture is produced as line drawings
    - Almost used in architectural and engineering layouts

Computer Graphics Systems

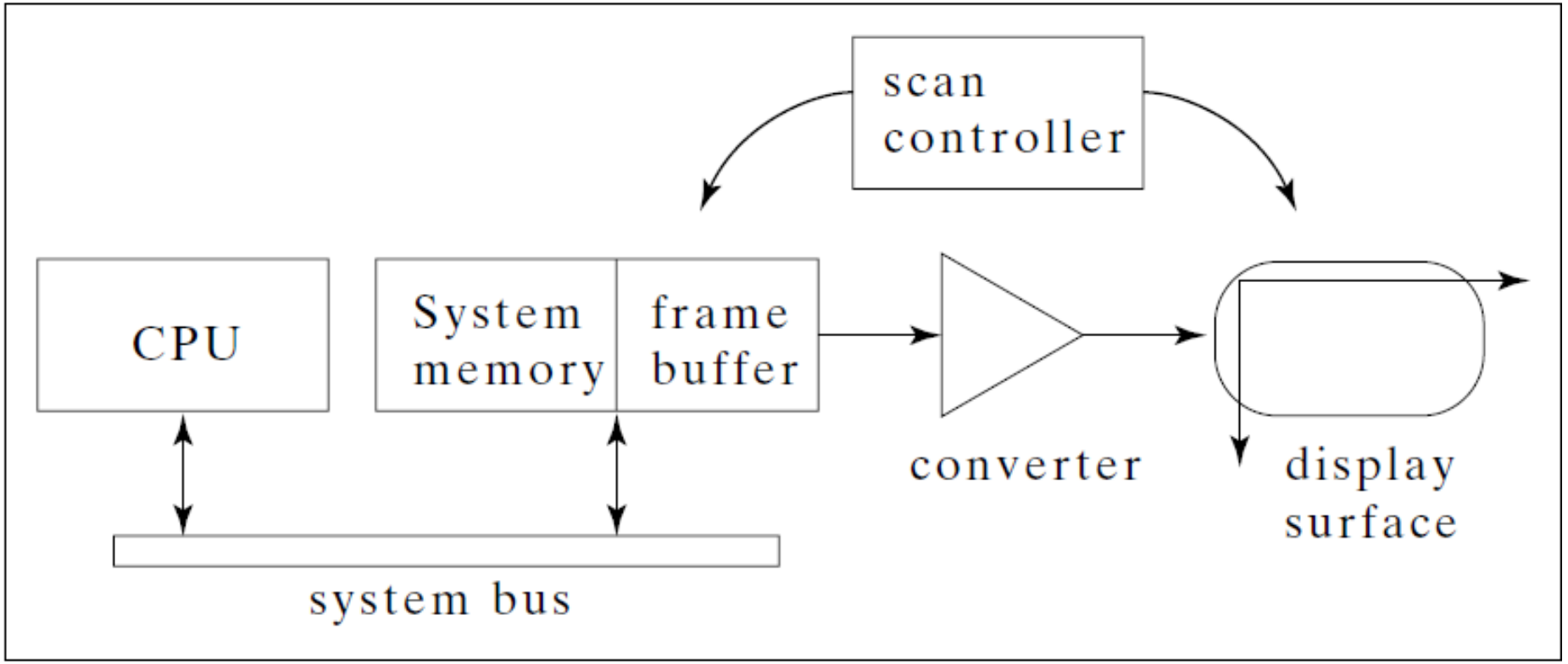
- Frame buffer
  - Pixel
    - **Is the smallest element of images**
    - **Image = 2D Array of pixels**
    - **Specification:**
      - →Location: (X,Y)
      - →Value:
        - Gray value
        - Color: [R,G,B]
        - Index to color

Computer Graphics Systems

- Frame buffer
  - **Store pixels of image to be shown on video display**
  - **Specification:**
    - Resolution: the number of pixels in the frame buffer
    - Depth or Precision: the number of bits that are used for each pixel
      - 1 bit: back and white color
      - 8 bits: 28 (= 256) colors
      - 24 bits: full-color system or true-color system.

Computer Graphics Systems

- Frame buffer



Computer Graphics Systems

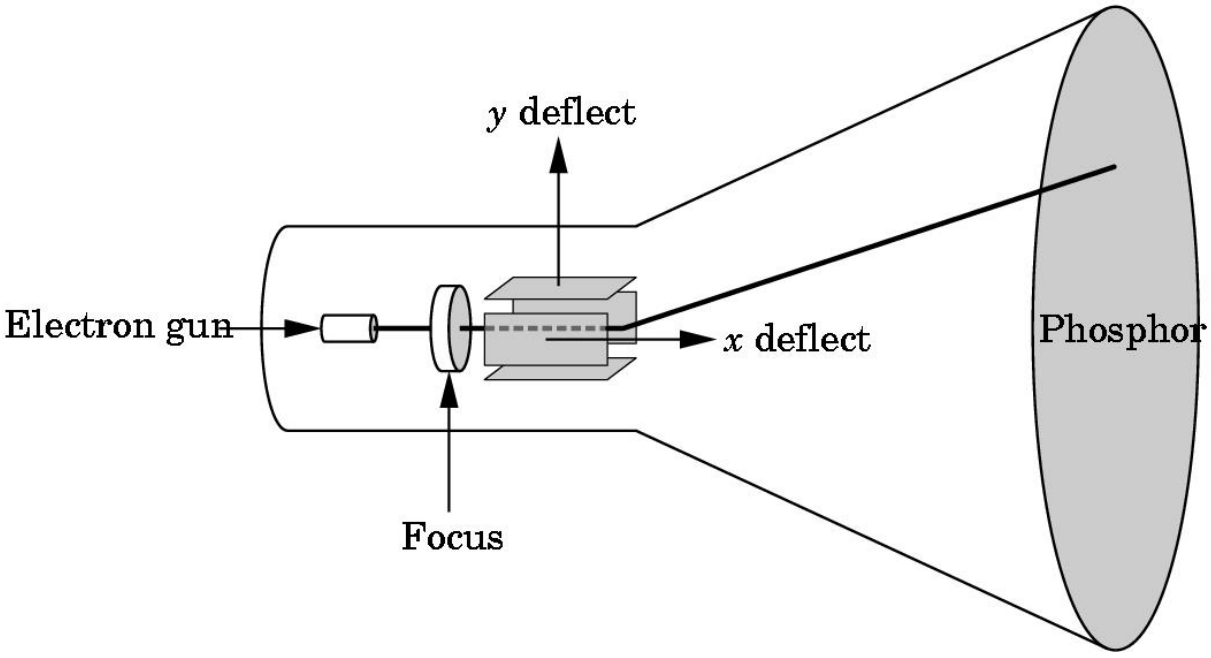
- Frame buffer
  - Color buffer, Depth buffer, Accumulation buffer v.v
  - Location
    - Inside the system memory
    - Inside GPU, graphic card

Computer Graphics Systems

- Output devices
  - **Hard-copy devices**
    - **Printer**
    - **Film recorder**
  - **Video display/projector**
    - Cathode-Ray Tube (CRT)
    - Flat-panel display.

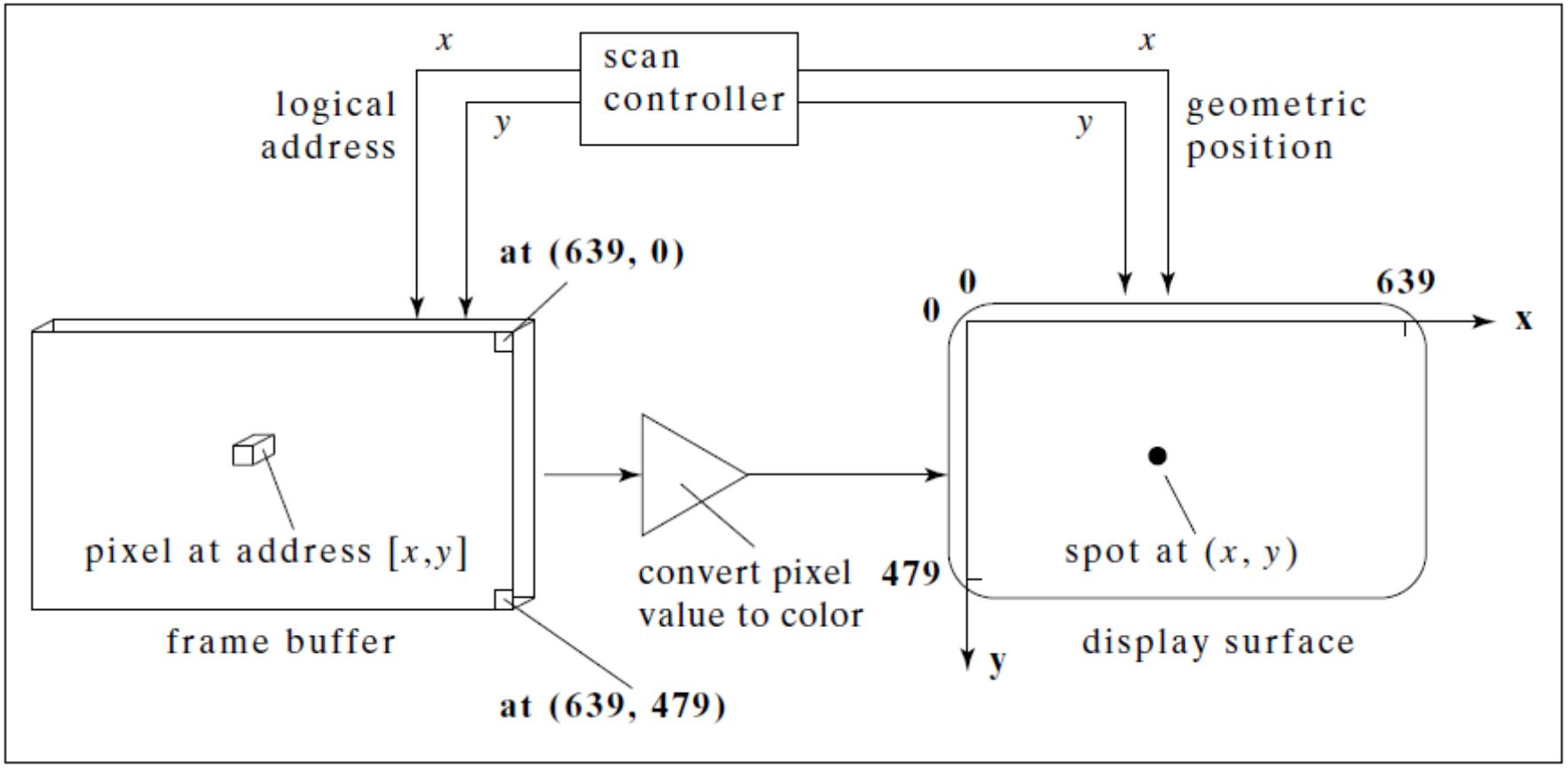
Computer Graphics Systems

- Output devices
  - CRT (*cathode ray tube*)



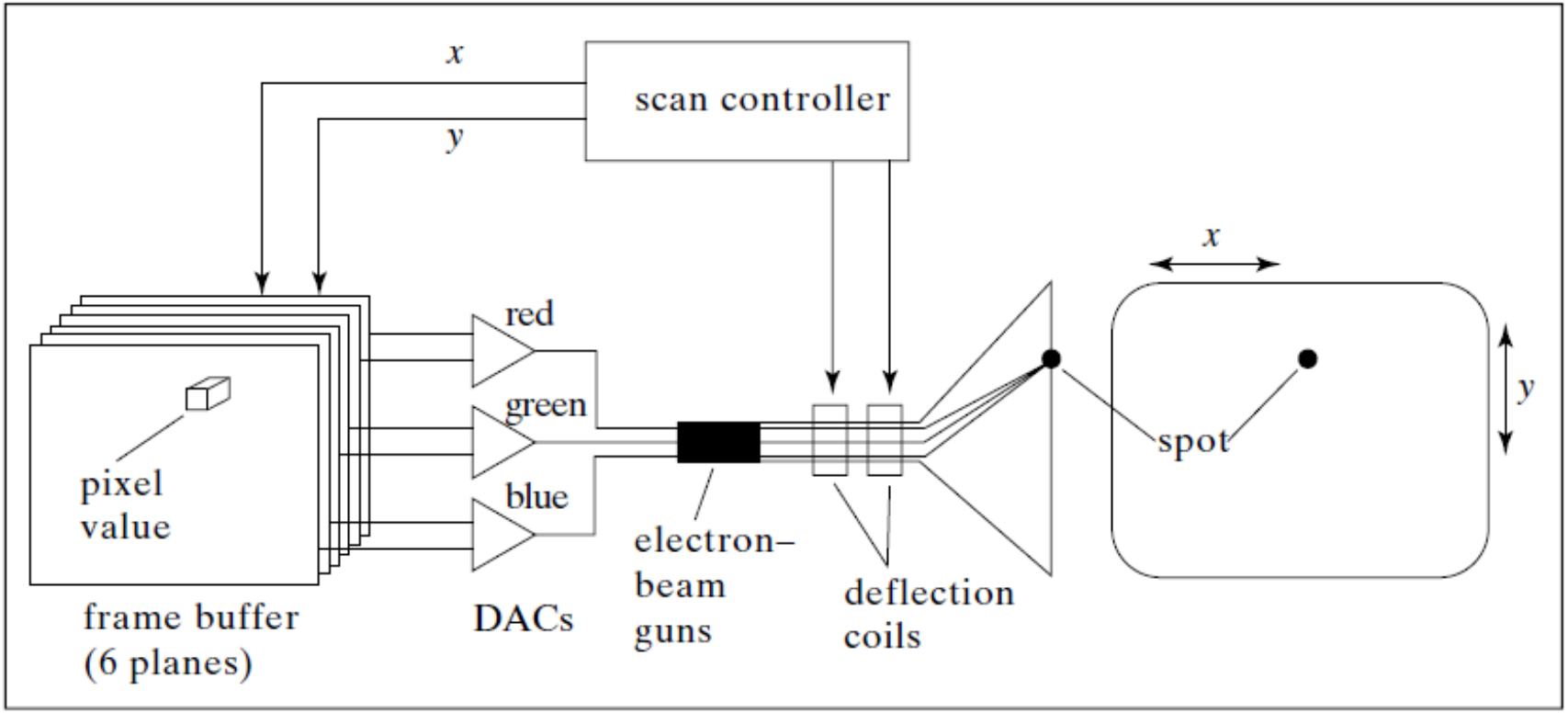
Computer Graphics Systems

- Output devices



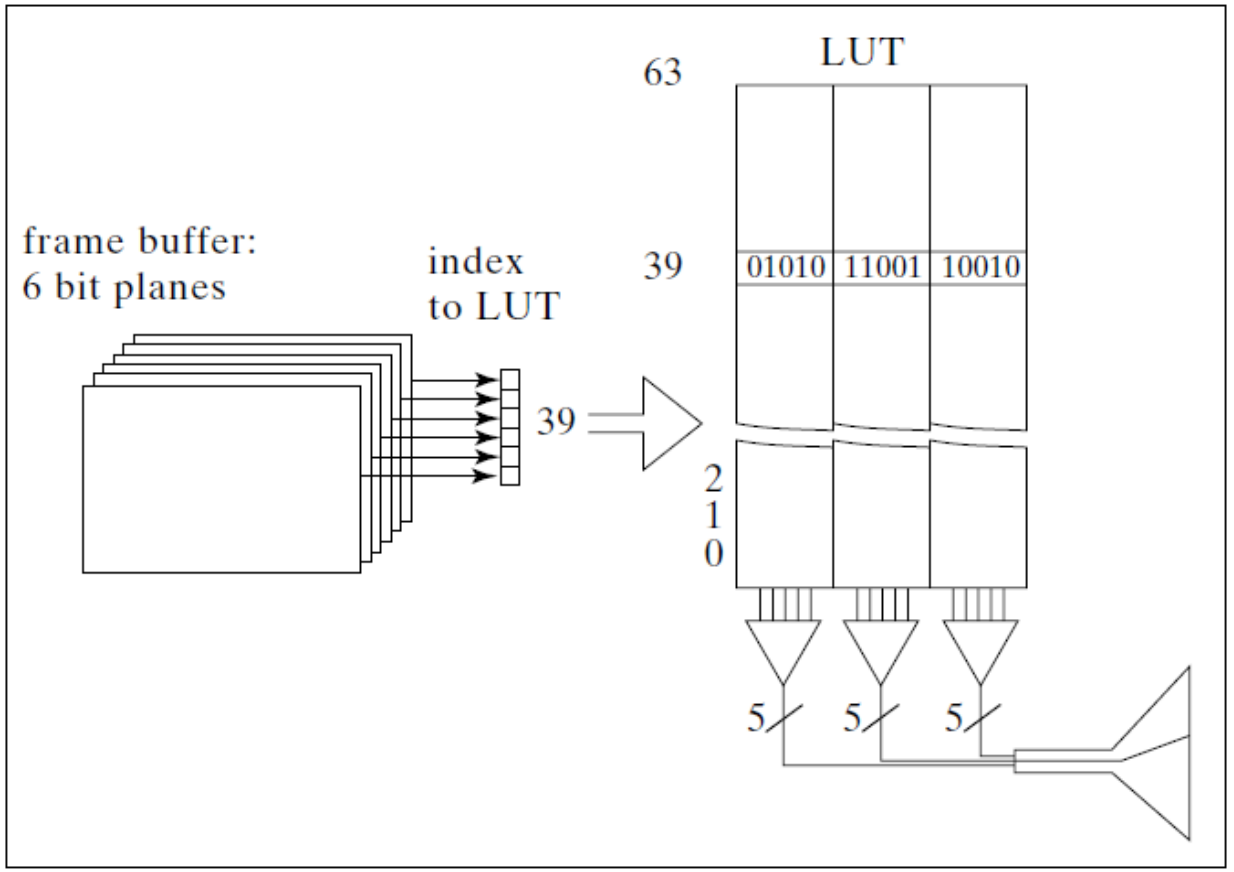
Computer Graphics Systems

- Output devices
  - Color CRT



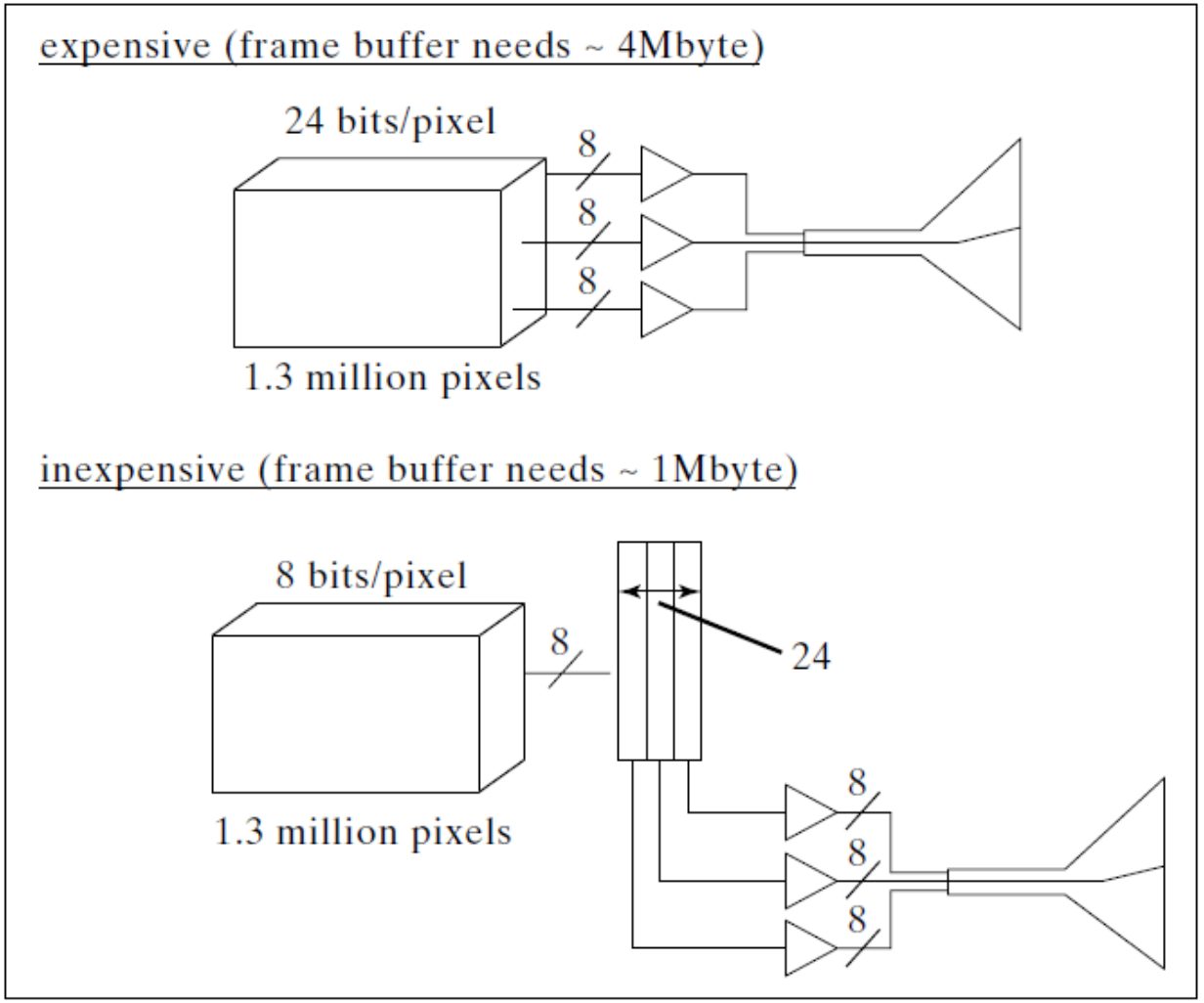
Computer Graphics Systems

- Output devices
  - Indexed Color & Look up table



Computer Graphics Systems

- Output devices



Computer Graphics Systems

- Output devices

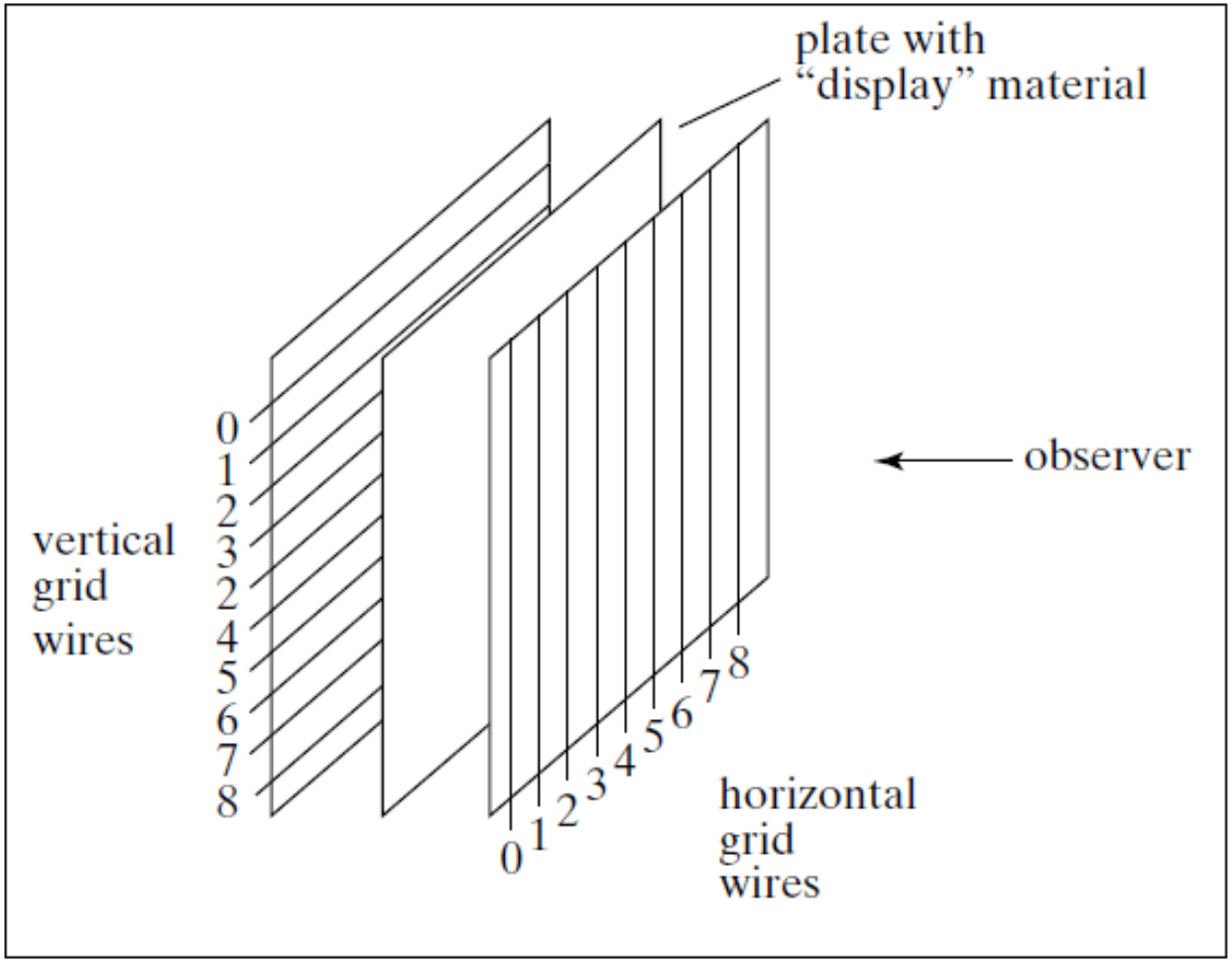


Image & Image Formation

- Elements of Image Formation
  - Objects
  - Viewers
  - Lights
- Advantages
  - Separation of objects, viewer, light sources
  - Two-dimensional graphics is a special case of three-dimensional graphics
  - Leads to simple software API
  - Leads to fast hardware implementation

Image & Image Formation

- Elements of Image Formation
  - Objects & viewers

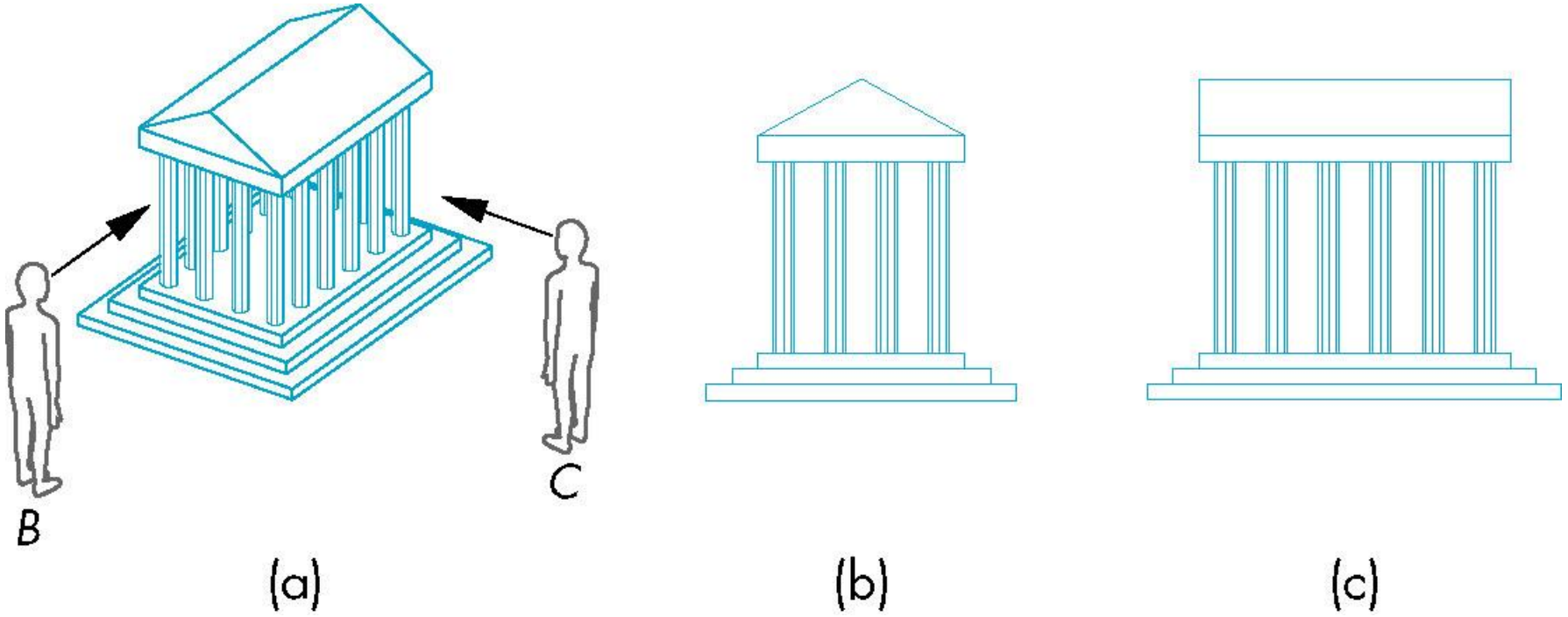


Image & Image Formation

- Elements of Image Formation
  - Objects & viewers

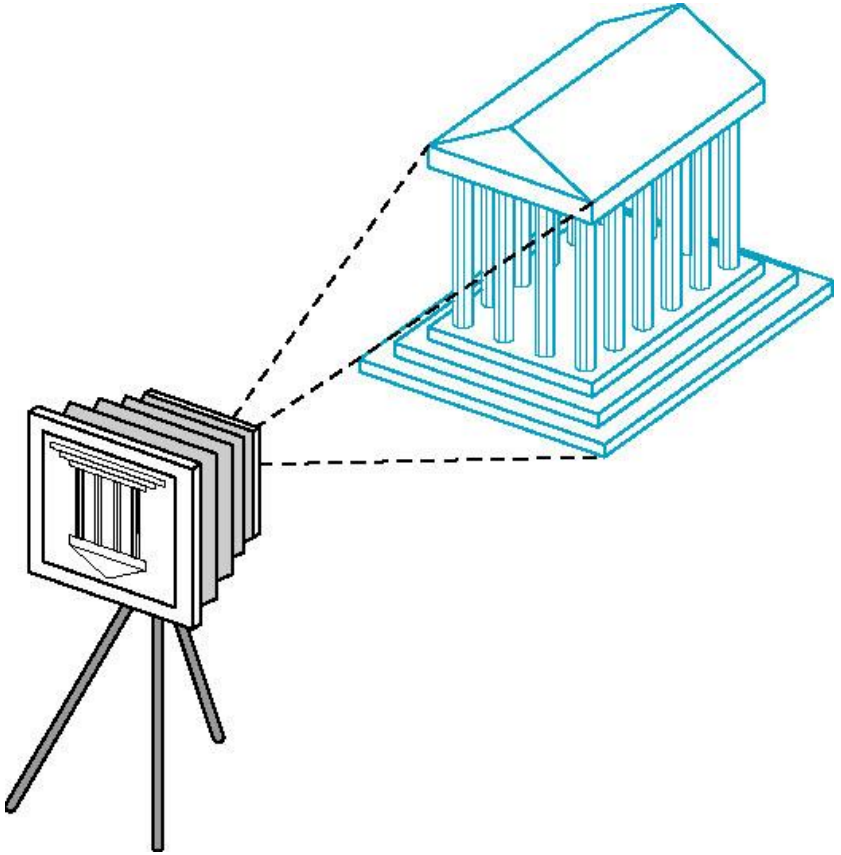


Image & Image Formation

- Elements of Image Formation
  - Lights

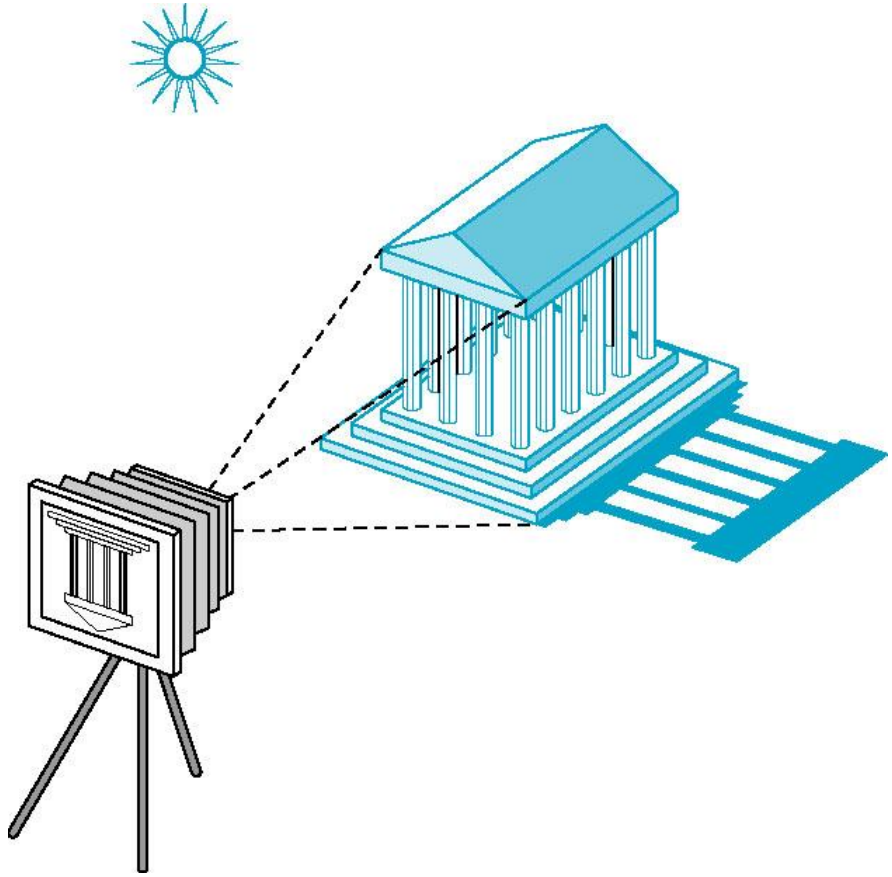
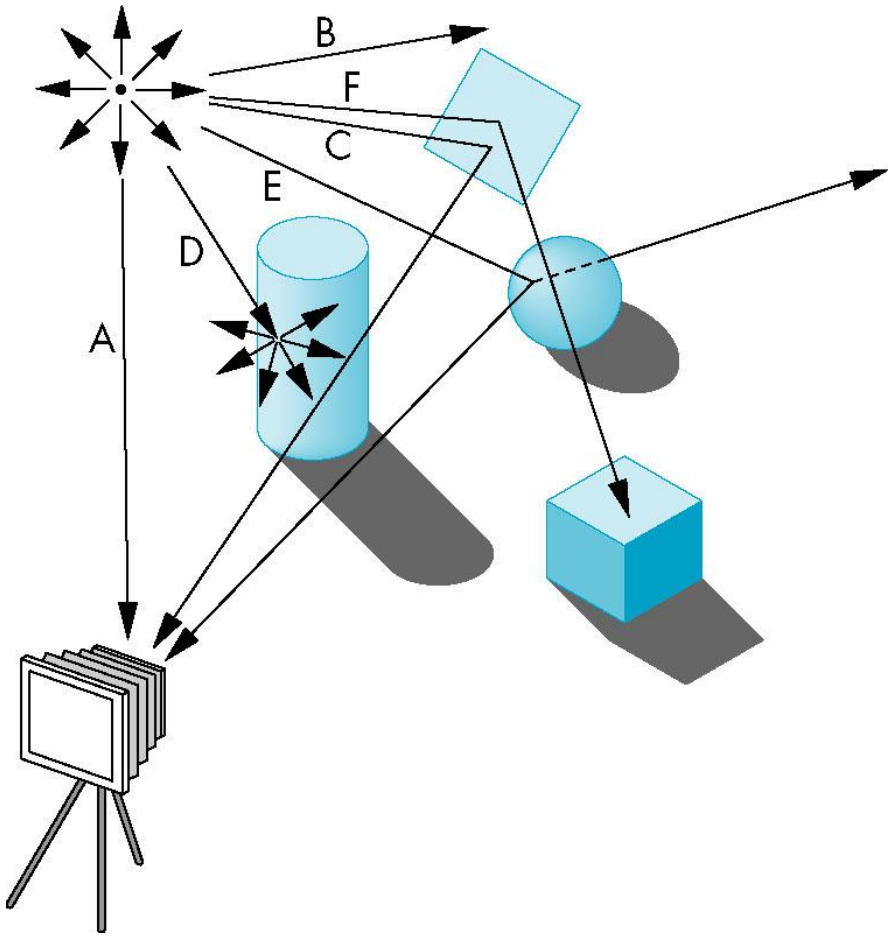


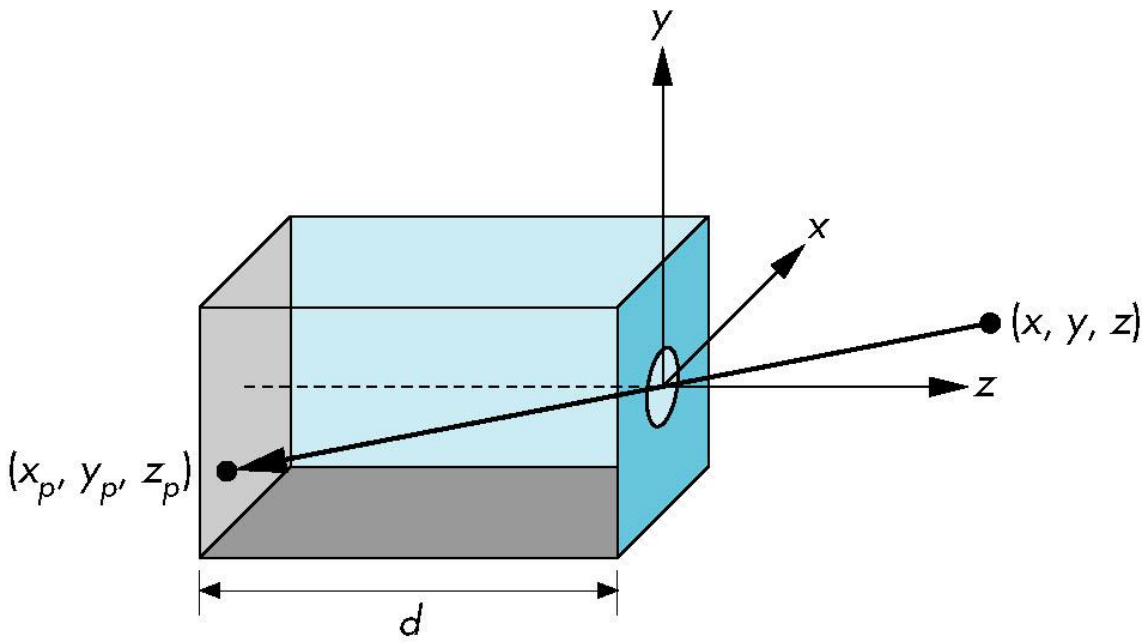
Image & Image Formation

Image Formation Model



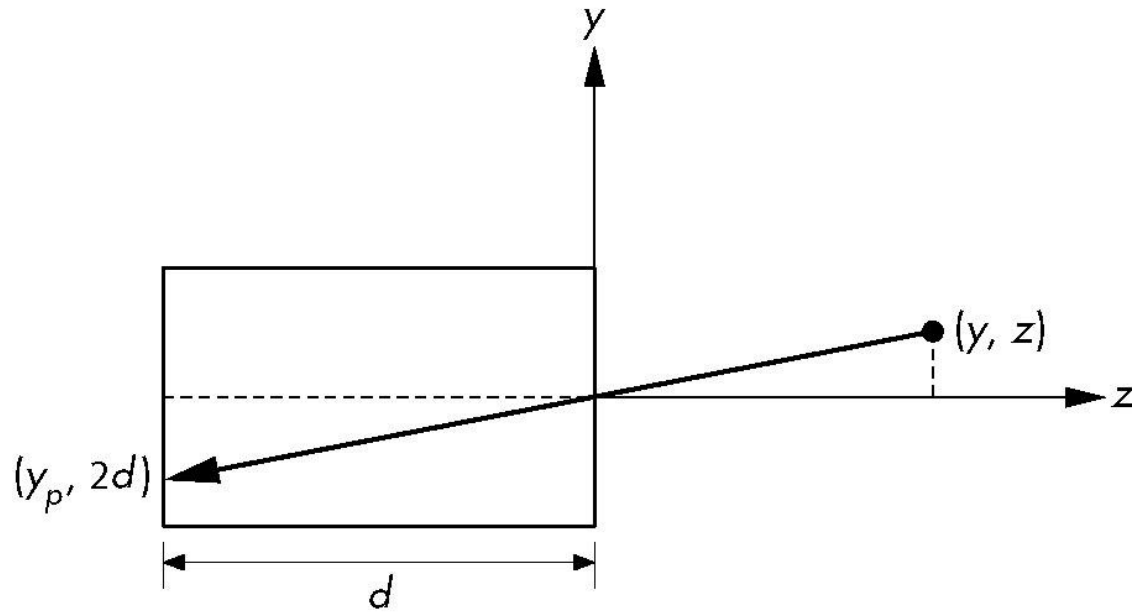
Camera

- Pinhole Camera



Camera

- Pinhole Camera
  - Use trigonometry to find **projection** of point at (x,y,z)



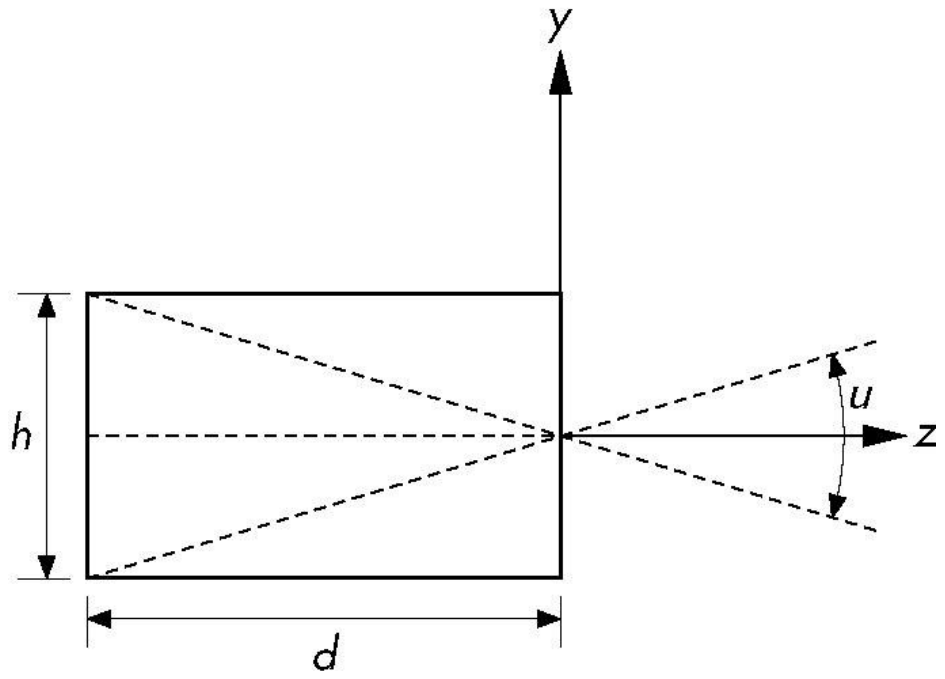
$$y_p = -\frac{y}{z/d}$$

$$x_p = -\frac{x}{z/d}$$

$$z_p = -d$$

Camera

- Pinhole Camera
  - **Field of view** (FOV), or angle of view



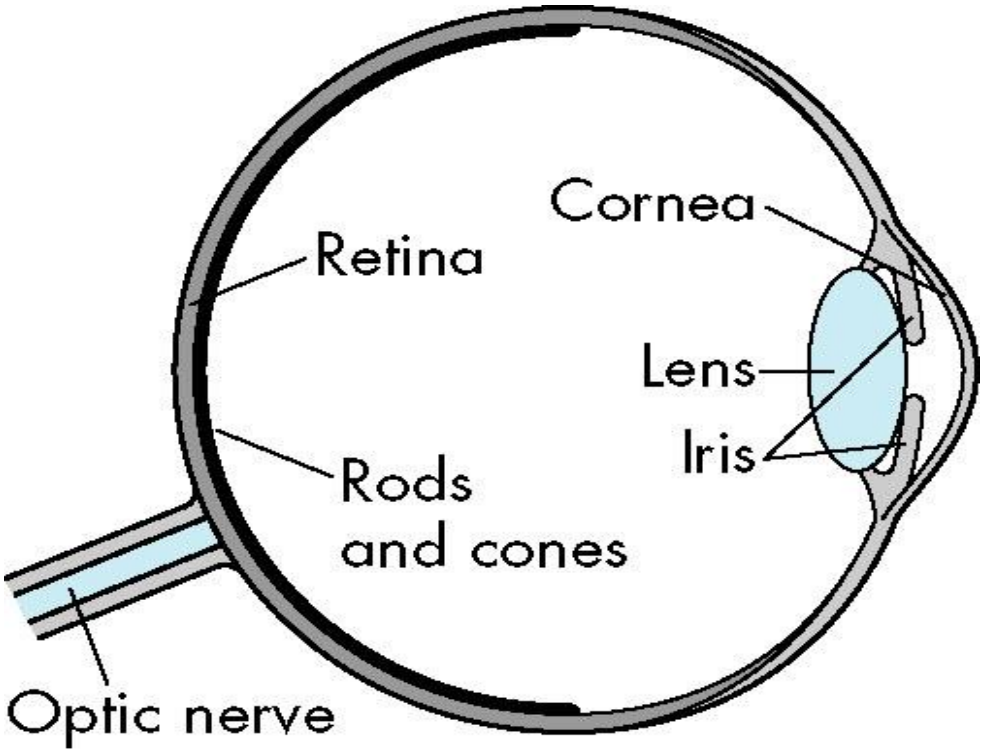
$$\theta = 2\tan^{-1}\frac{h}{2d}$$

Camera

- Pinhole Camera
  - Infinite depth of field
  - The pinhole so small – admits only a single ray from a point source
  - Cannot be adjust to have a different angle of view

Camera

- Human visual system

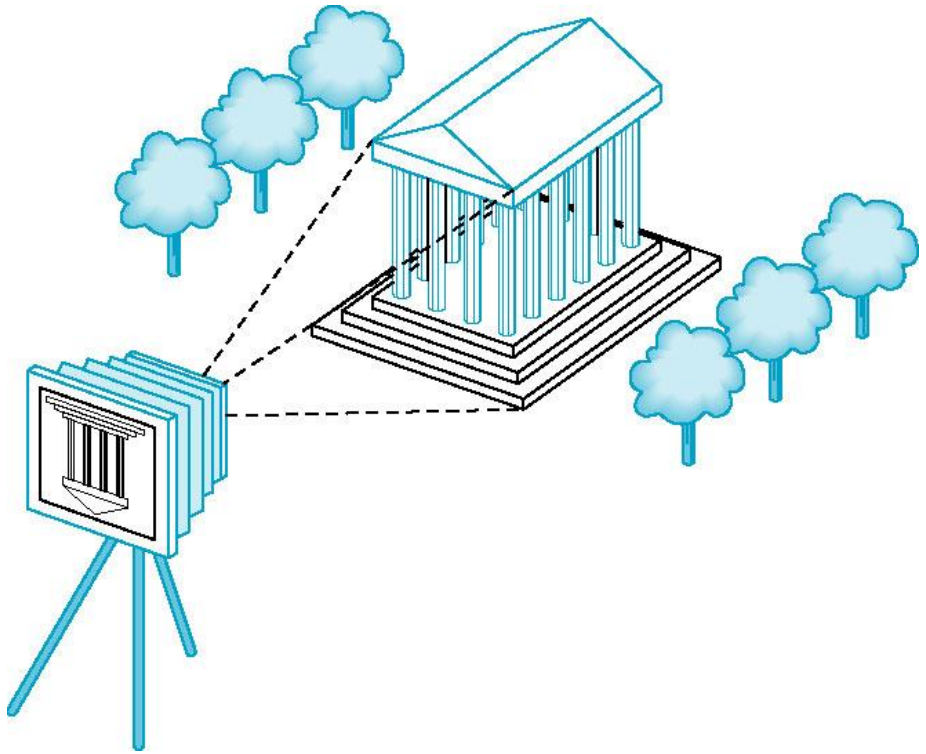


Camera

- Human visual system has two types of sensors
  - Rods: monochromatic, night vision
  - Cones
    - Color sensitive
    - Three types of cones
    - Only three values (the *tristimulus* values) are sent to the brain

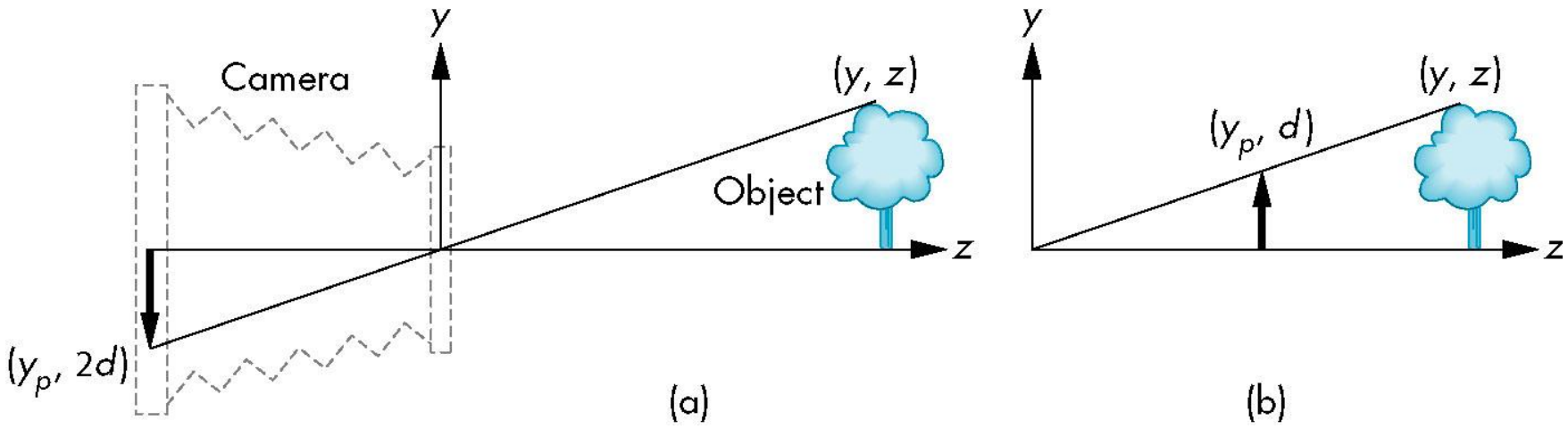
Camera

- Synthetic camera model



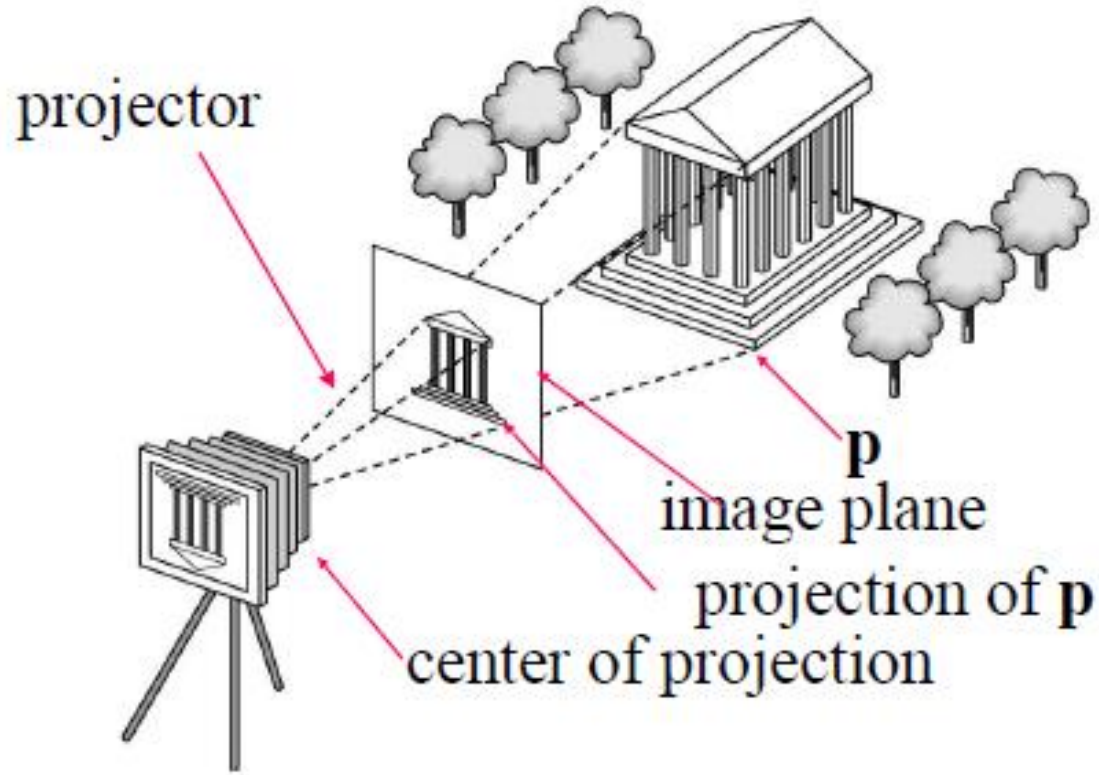
Camera

- Synthetic camera model
  - Center of projection (COP)
  - Projector
  - Projection plane



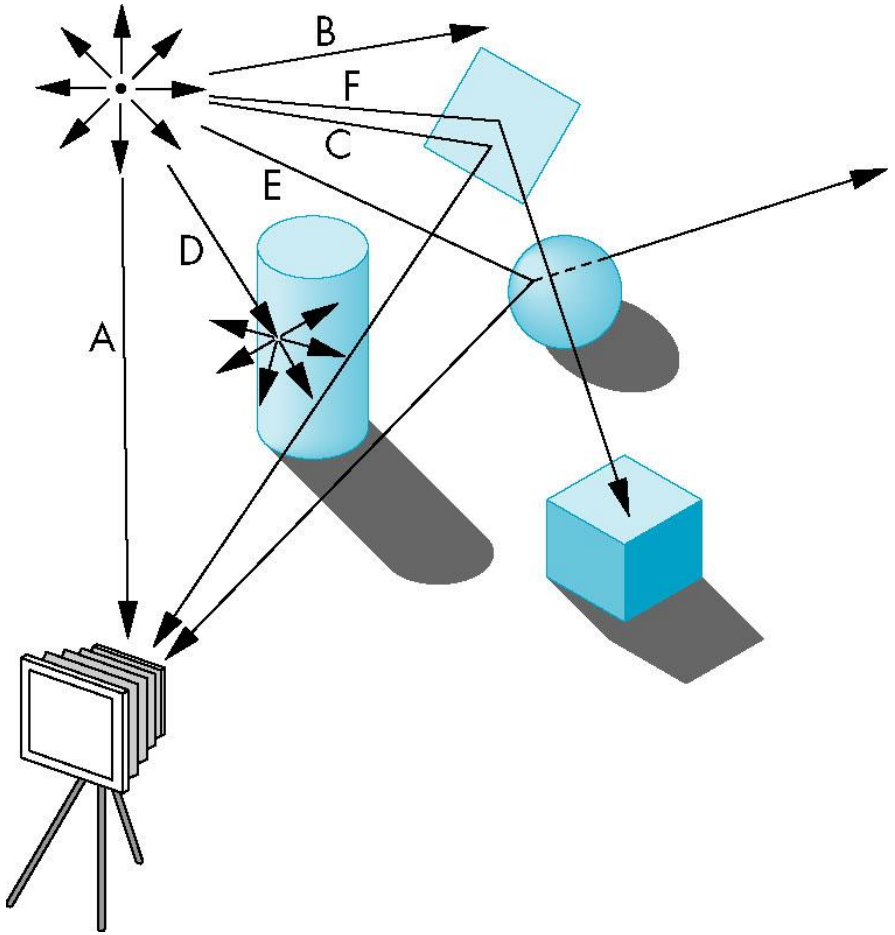
Camera

- Synthetic camera model



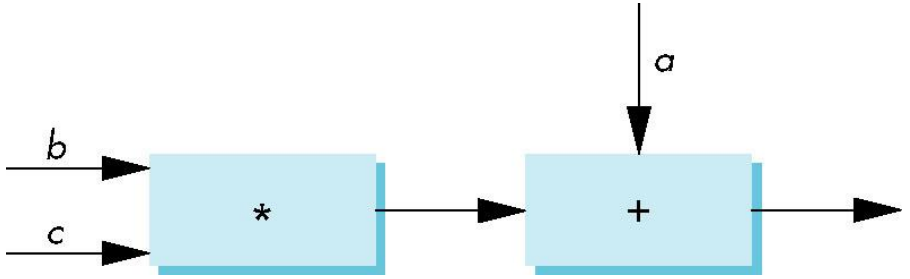
Models and Architectures

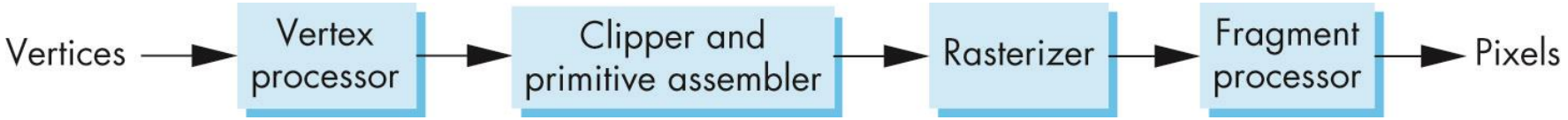
- Physical Approaches: Ray tracing



Models and Architectures

- Practical Approach : Pipeline
  - Fast, simple
  - All steps can be implemented in hardware on the graphics card





API Contents

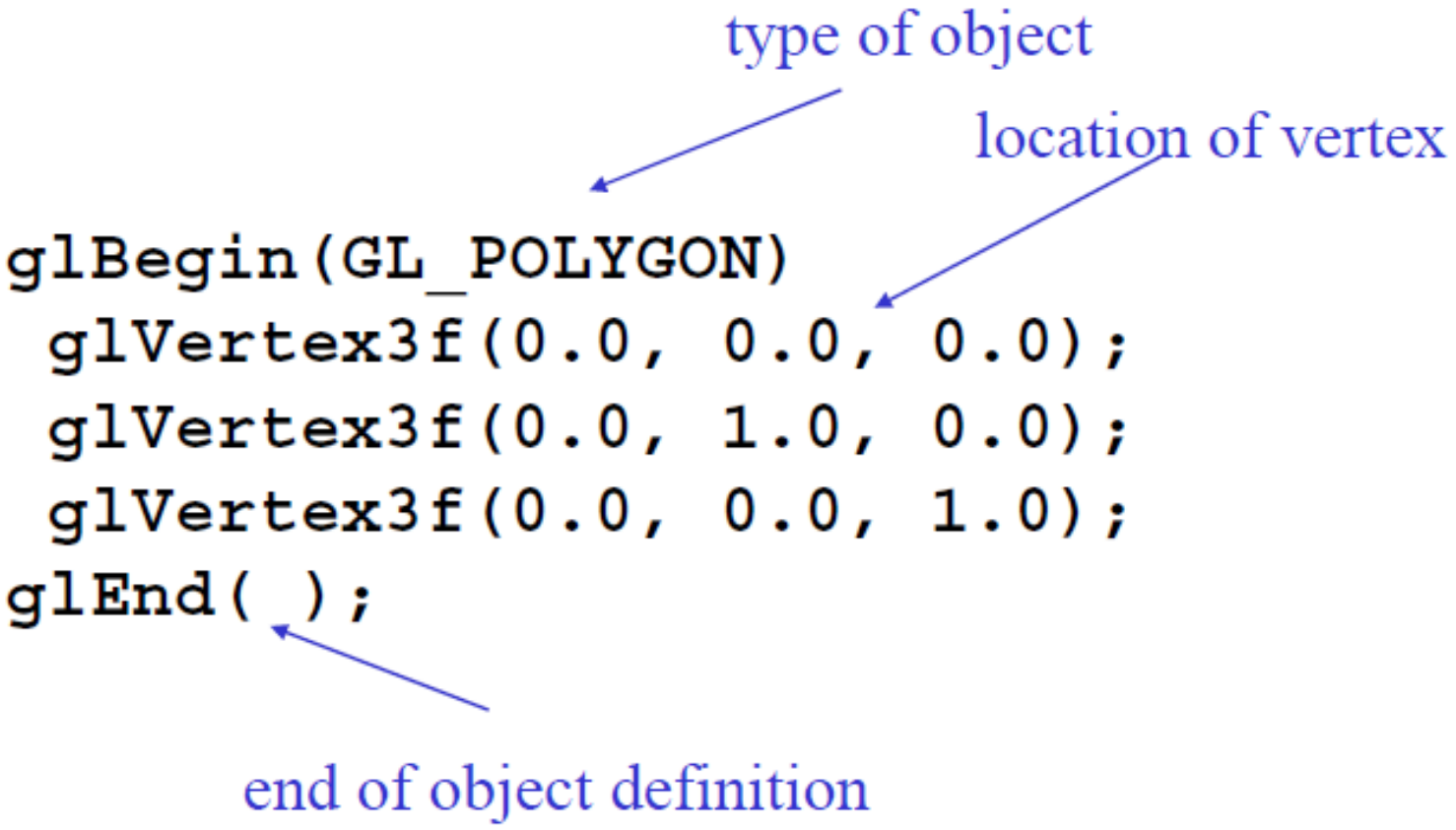
- Functions that specify what we need to form an image
  - **Objects**
  - **Viewer**
  - **Light Source(s)**
  - **Materials**
- Other information
  - **Input from devices such as mouse and keyboard**
  - **Capabilities of system**

API Contents

- Object Specification
  - Most APIs support a limited set of primitives including
    - **Points (0D object)**
    - **Line segments (1D objects)**
    - **Polygons (2D objects)**
    - **Some curves and surfaces**
  - All are defined through locations in space or *vertices*

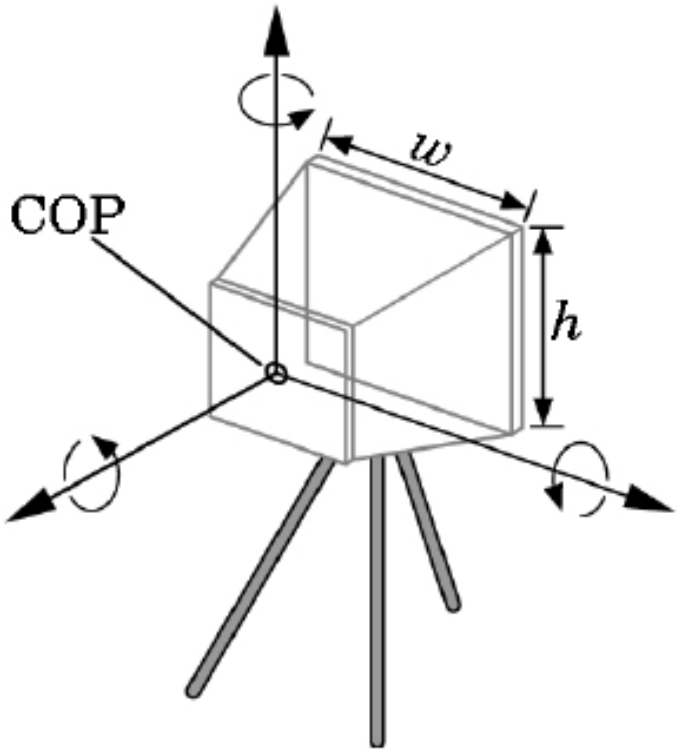
API Contents

- Object Specification



API Contents

- Camera Specification
  - Six degrees of freedom
    - **Position of center of lens**
    - **Orientation**
    - **Lens**
    - **Film size**
    - **Orientation of film plane**



API Contents

- Lights and Materials
  - Types of lights
    - **Point sources vs distributed sources**
    - **Spot lights**
    - **Near and far sources**
    - **Color properties**
  - Material properties
    - **Absorption: color properties**
    - **Scattering**
      - →Diffuse
      - →Specular

Further Reading

- "**Interactive Computer Graphics: A Topdown Approach Using OpenGL**", *Edward Angel*
  - Chapter 1: Graphics Systems And Models
- "Đồ họa máy tính trong không gian hai chiều", Trần Giang Sơn
  - Chương 1: Giới thiệu đồ họa máy tính