Introduction to Computer Graphics

Spring 2021

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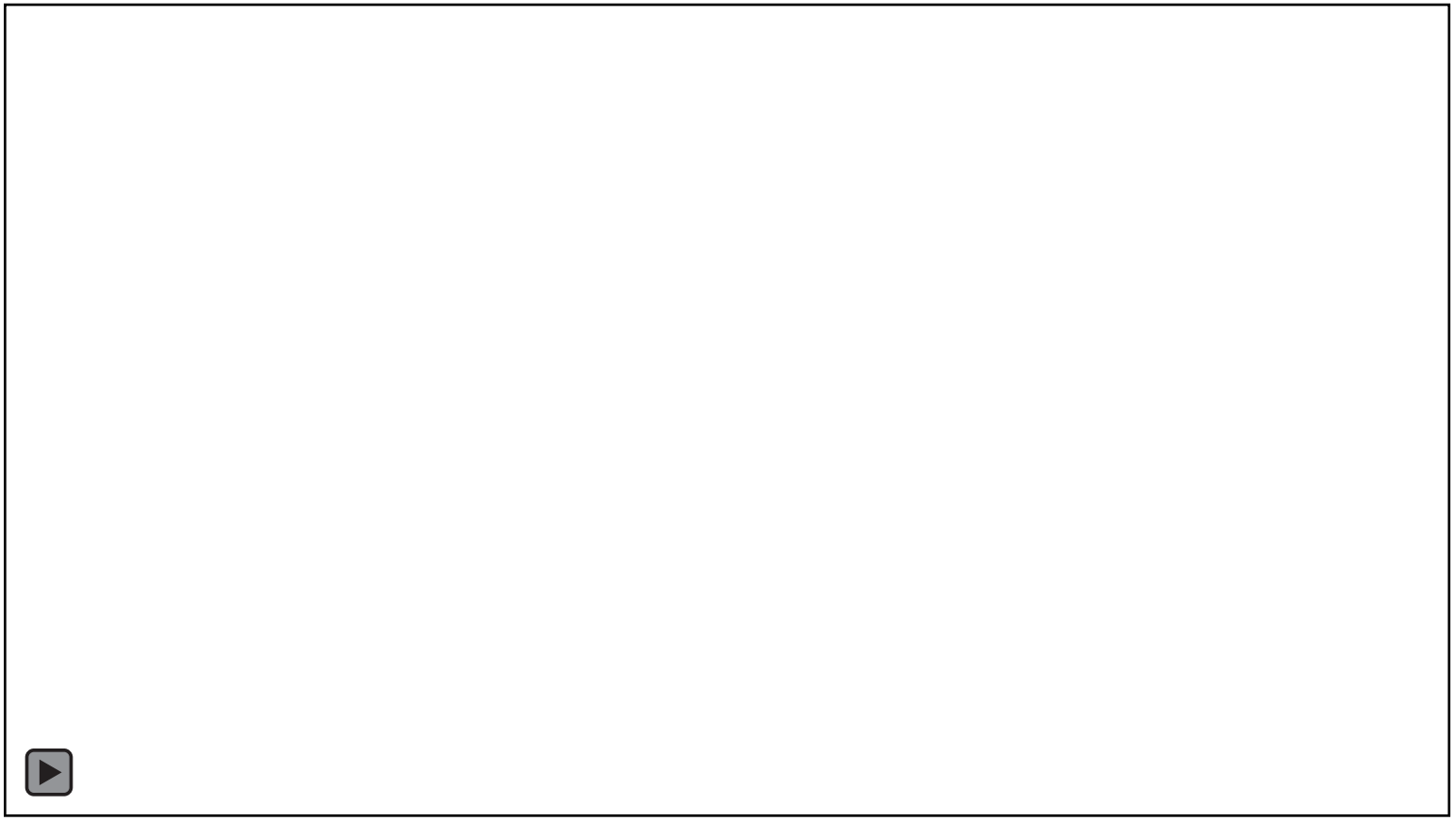
POSTECH

(Some slides from textbook materials)

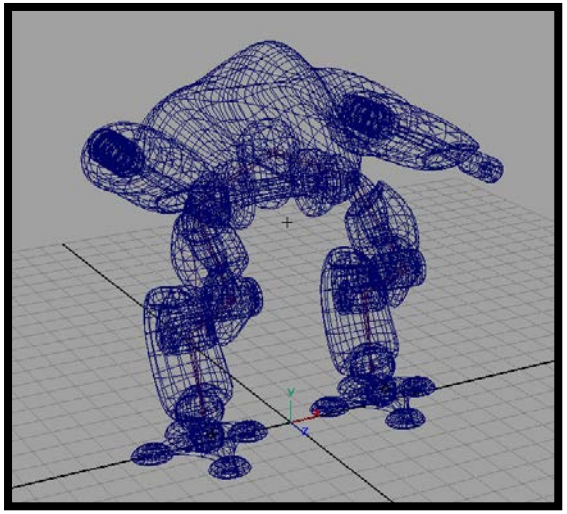
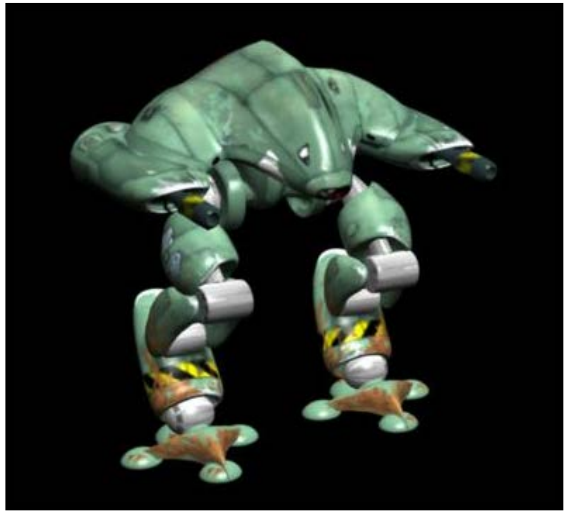
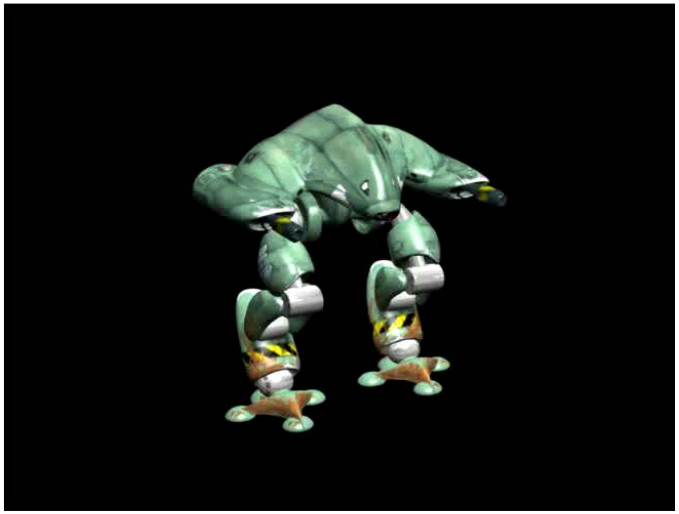
Computer Graphics

- What is computer graphics?
  - creation, storage, and manipulation of models to generate images (pictures) and animations



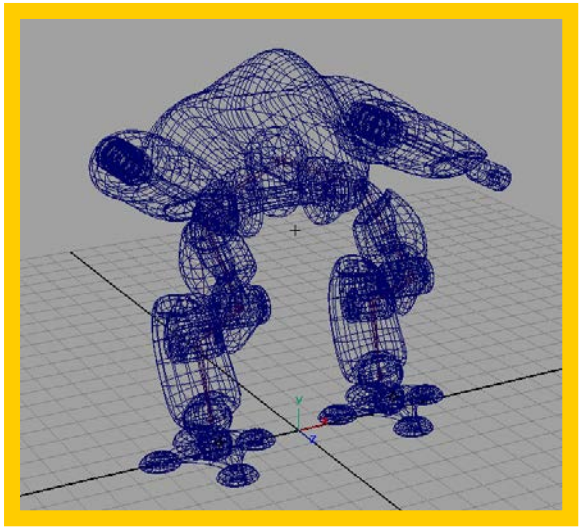
Three Main Topics in Graphics

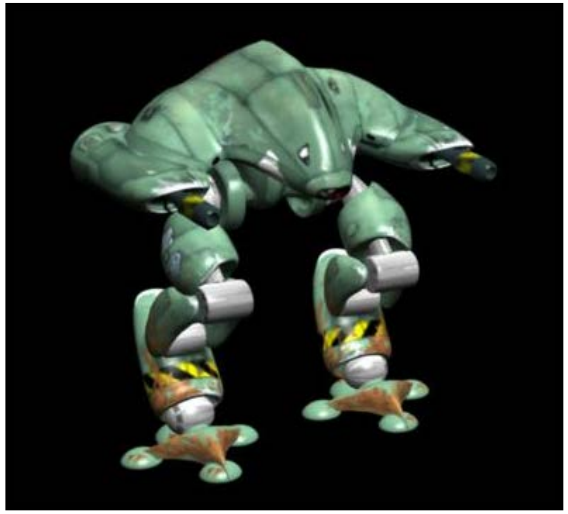
- Modeling
- Rendering
- Animation

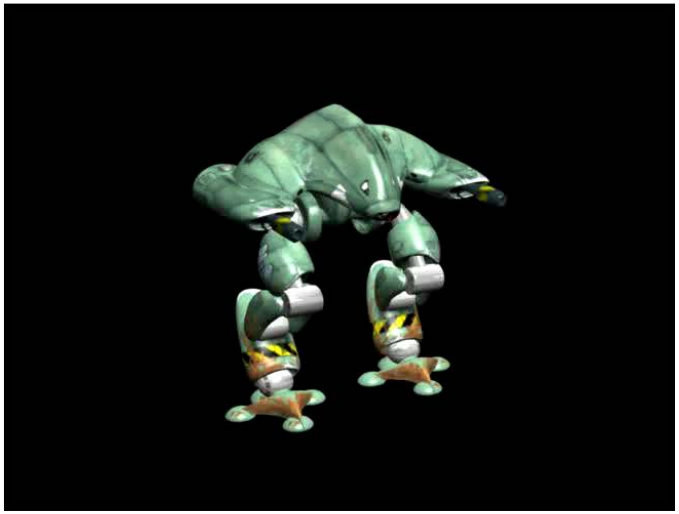




Modeling

- How to represent things?
- How to build those representations?



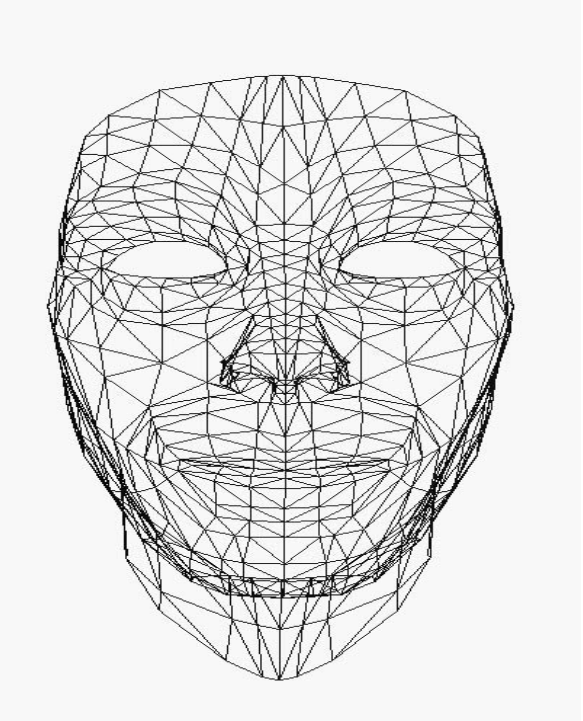




Shape Representation

- Geometric information
  - 3D positions
  - vertices
  - edges
  - faces

v1=(0, 0, 0), v2=(100, 0, 0), …
e1=(v1, v2), e2=(v1, v3), …
f1=(v1, v2, v3), f2=(v1, v2, v5), …

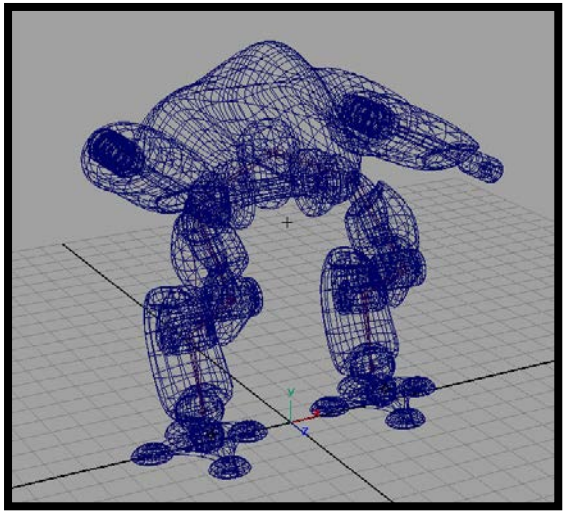


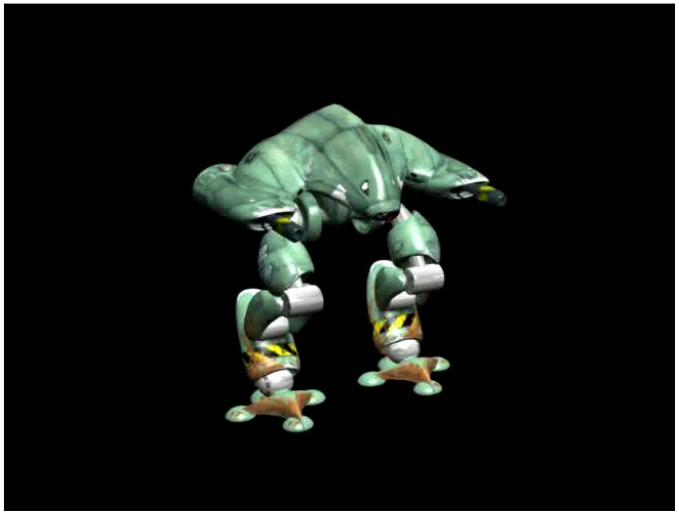
Shape Construction

- Modeling software
- 3D scanning

Rendering

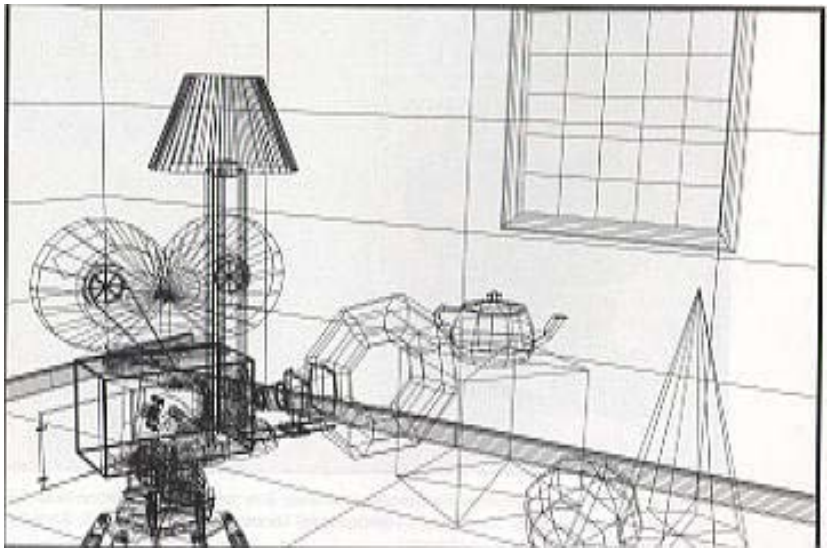
- How to simulate image-forming process?
- How to generate realistic (impressive) images from a 3D model?

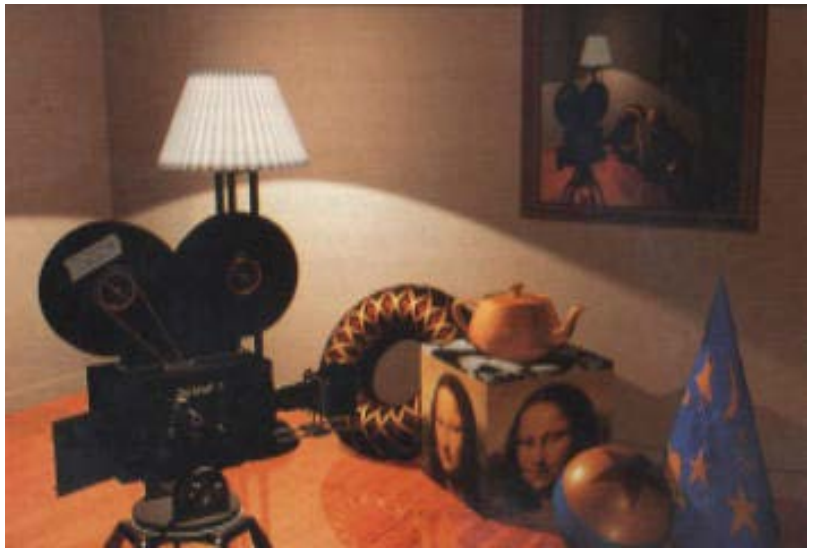




Rendering Process

- Realistic image synthesis





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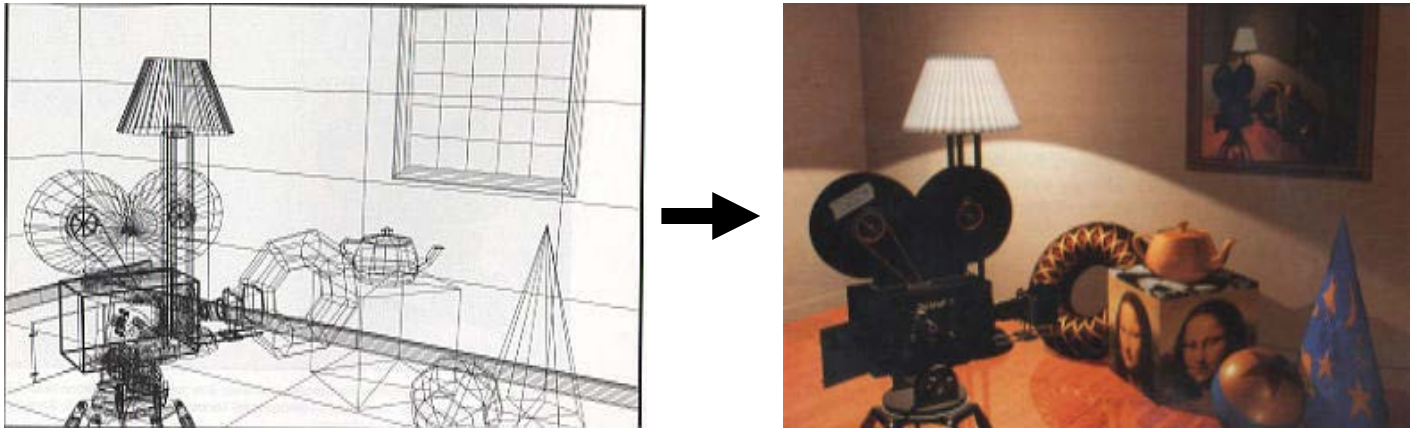
e1=(v1, v2), e2=(v1, v3), …
f1=(v1, v2, v3), f2=(v1, v2, v5), …

Pixel array
RGB values

Rendering Process (2)

- Approaches
  - virtual camera model
  - light source and material property
  - photo-realistic image



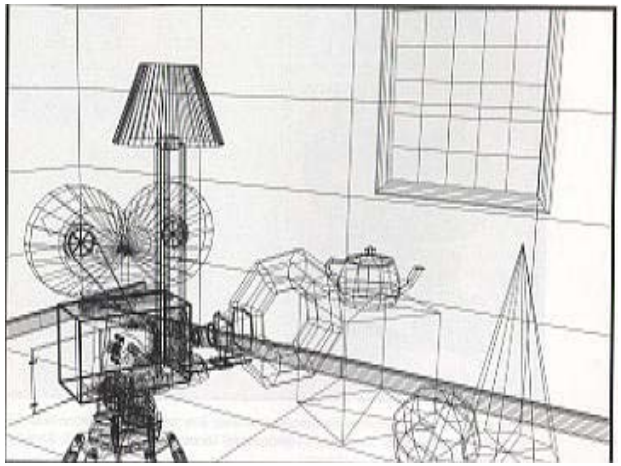
v1=(0, 0, 0), v2=(100, 0, 0), …

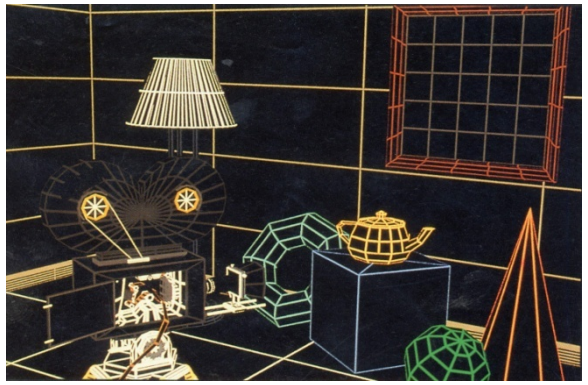
Rendering Process (3)

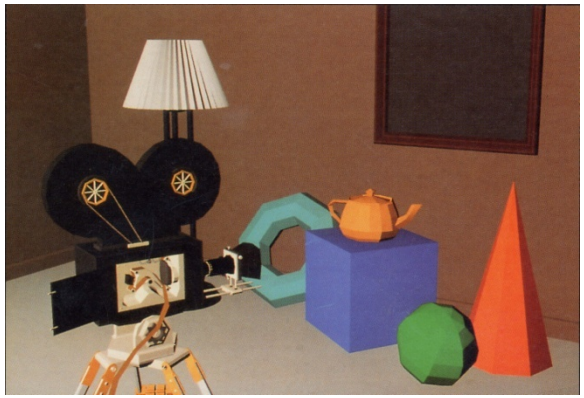
- Projection, lighting, and texturing

3D Models

v1=(0, 0, 0), v2=(100, 0, 0), …
e1=(v1, v2), e2=(v1, v3), …
f1=(v1, v2, v3), f2=(v1, v2, v5), …



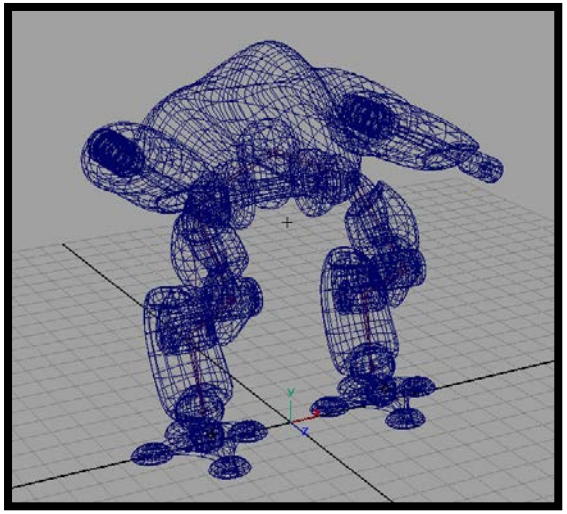


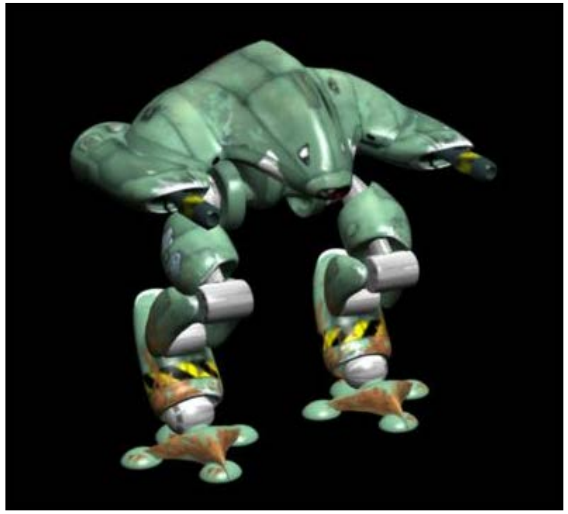


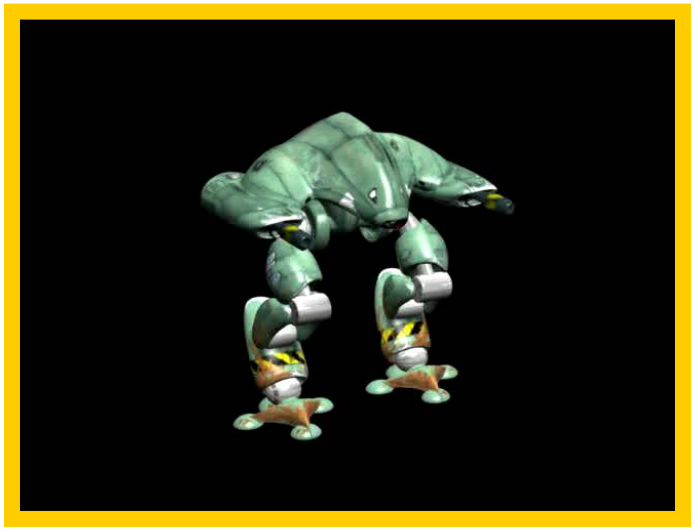
Rendering Example

Animation

- How to represent motions?
- How to control the way things move?

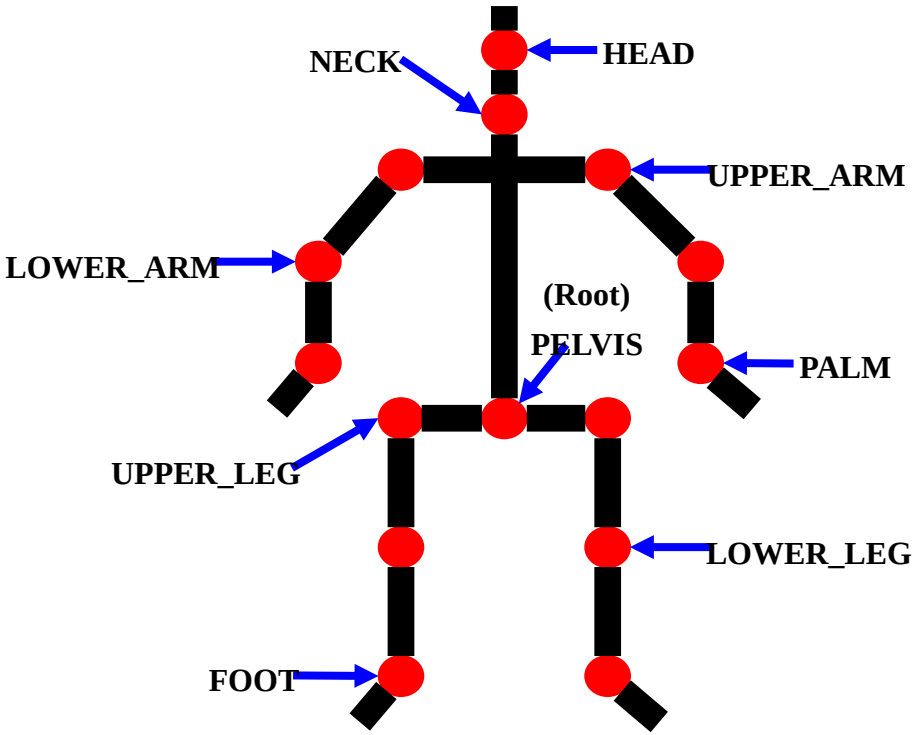






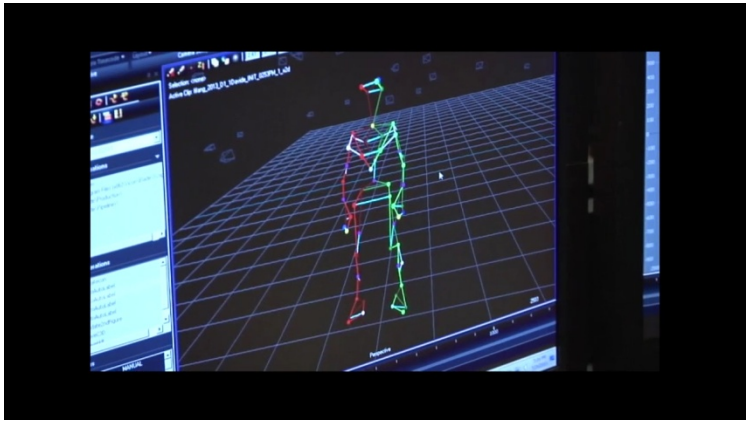
Motion Representation

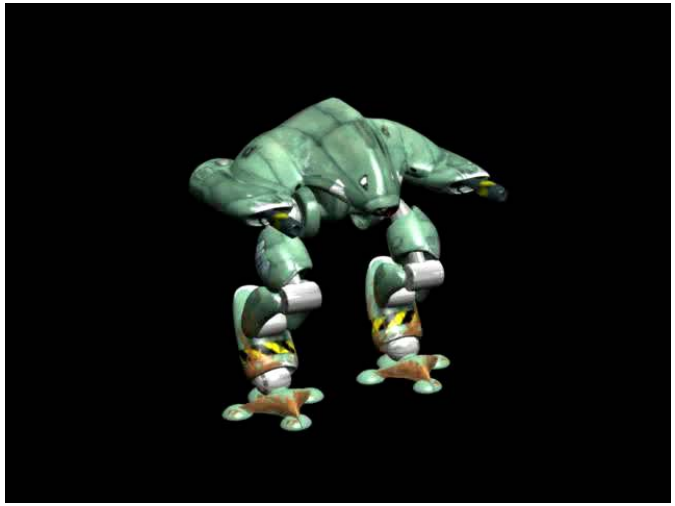
- Simple motion of a particle
  - position as a function of time
- Hierarchical model
  - skeleton
  - joint angles



Motion Control

- Key frame animation
  - key frames
  - interpolation
- Motion capture
  - realistic motion



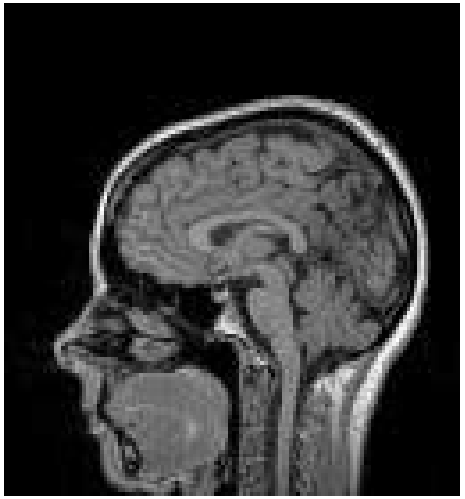


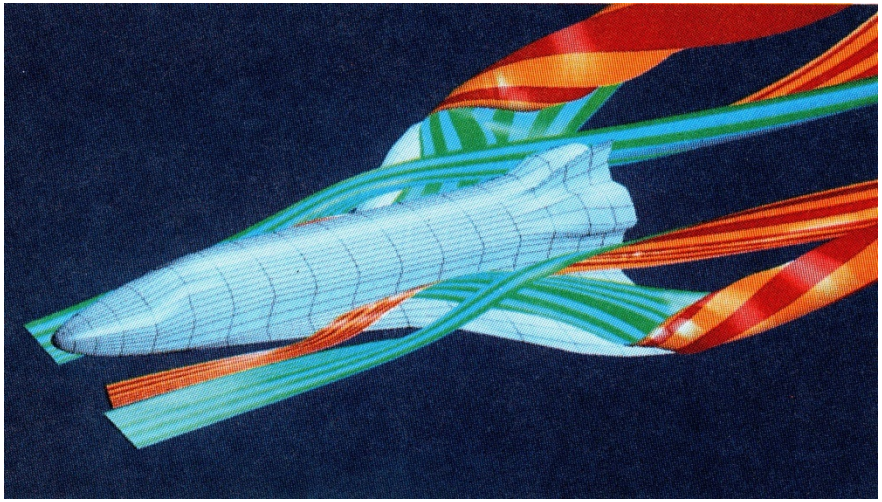
Why Computer Graphics?

- Advantages of (interactive) graphics
  - most important means of producing pictures since the invention of photography and television
  - pictures of not only of concrete, real-world objects, but also of abstract, synthetic objects and of data
  - extensive, high-bandwidth user-computer interaction
  - helps to understand data, to perceive trends, and to visualize real or imaginary objects
- We can draw whatever we can imagine!!!

Why Computer Graphics?

- Applications
  - entertainment (games, animations)
  - visualization (medicine, scientific visualization)
  - education and training
  - computer-aided design





Related Areas

- Computer vision & Image processing

	input	output	objective
computer graphics	model descriptions	images	realistic images
computer vision	images	model descriptions	accurate descriptions
image processing	images	images	more useful images

- Virtual reality
  - real-time graphics + user interaction
  - speed is more important than quality

Graphics System

- Computer graphics deals with all aspects of creating images with a computer
  - Hardware
  - Software
  - Applications

Example

- Where did this image come from?

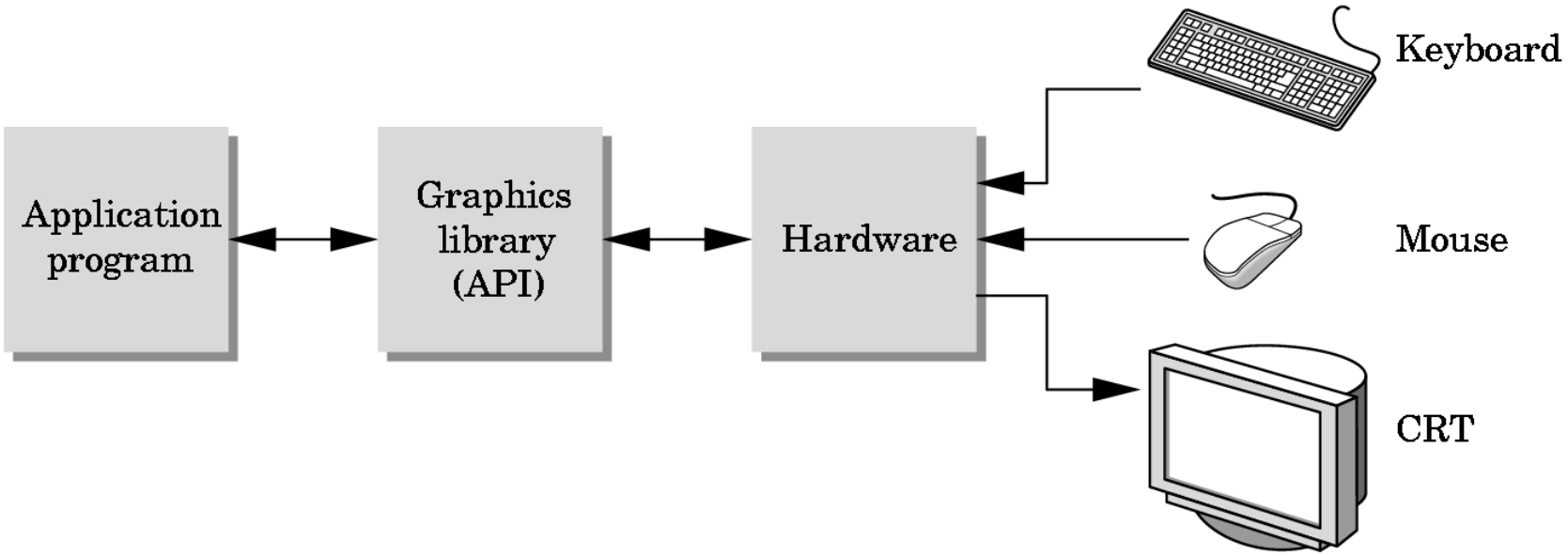
- What hardware/software are needed to produce it?

A Simple Answer

- Application: Program to model and render the object with the desired appearance
- Graphics library: OpenGL providing basic graphics functions for modeling and rendering
- Hardware: PC with graphics card for modeling and rendering

The Programmer's Interface

- Programmer sees the graphics system through a software interface: the Application Programmer Interface (API)



API Contents

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

Course Objectives

- Understanding a graphics system
  - design and structure of a graphics system
  - internal implementation of a graphic system
- Learning how to use a graphics system
  - developing 2D and 3D graphics applications with a graphics system
- OpenGL as the choice of the graphics system
  - concepts and implementations are well matched
  - first legacy OpenGL
  - finally programmable shaders

Summary

- Introduction to graphics
  - modeling, rendering, animation
  - We can generate an image or animation of whatever we can imagine!!!
- Graphics system as the programmer's interface
- Course objectives
- Angel: Chapter 1 → Reading assignment!!

Supplementary Slides

Brief History of Computer Graphics

- Plotters → CRT (1950's) → Sketchpad (1963)
- CAD/CAM: DAC (1964), Itek Digitex (1960's)
- Interactive graphics at few organizations (1970's)
- PCs with graphics displays (1980's)
  - inexpensive graphics-based user interfaces
  - bitmap graphics, pixels
  - desktop, windows, mouse
  - direct manipulation (pointing and clicking)

Brief History of Computer Graphics (2)

- 1990's advances
  - Silicon Graphics for 3D graphics
  - animation packages
  - advances in PC graphics
  - graphics effects in commercials and movies
  - Toy Story
- 2000's advances
  - high performance PC graphics card
  - game consoles with high quality graphics
  - full 3D games, on-line games
  - standard graphics toolkits and engines

Brief History of Computer Graphics (3)

- What is the future?
  - graphics is everywhere!
  - animation movies
  - virtual environments
  - 3D display device
  - mobile graphics
  - synthetic actors
  - new graphics paradigm
  - …

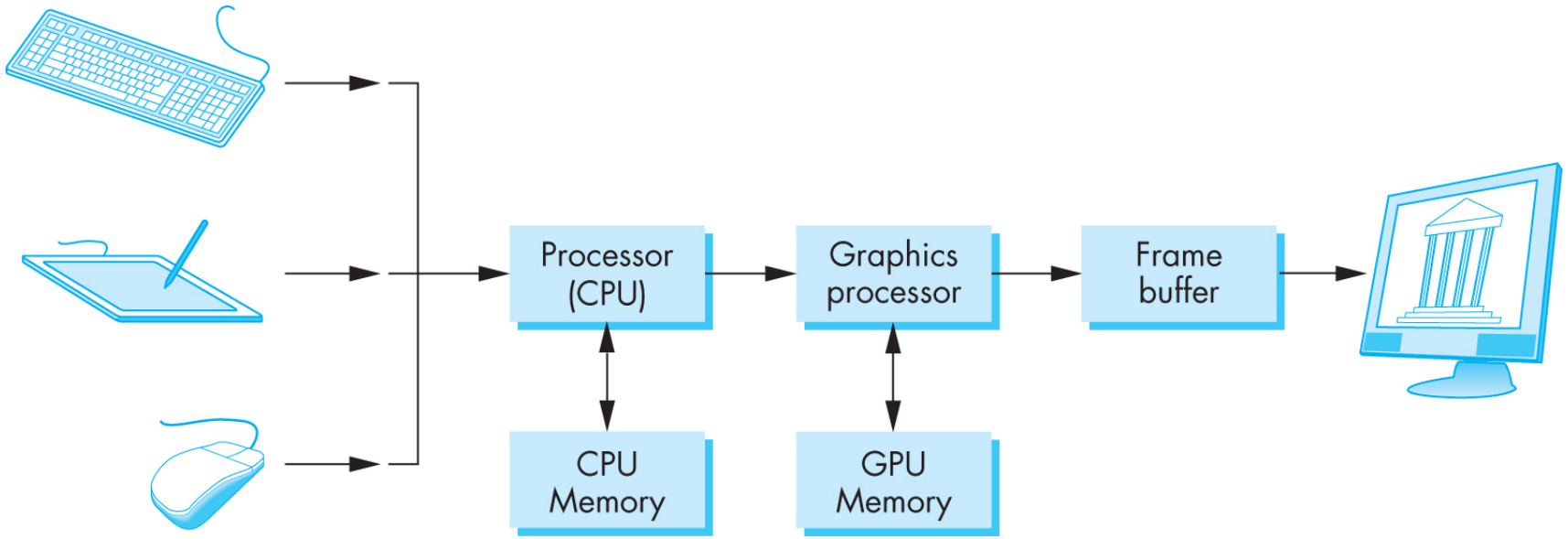
Software Portability and Graphics Standards

- Why graphics standards?
  - similar to high-level programming languages
- Official standards
  - Core by ACM SIGGRAPH (1977)
  - GKS by ANSI and ISO (1985)
  - GKS-3D (1988)
  - PHIGS (1988)
  - PHIGS+ (1988), PHIGS PLUS (1992)

Software Portability and Graphics Standards

- Industry standards
  - X Lib, PEX
  - PostScript (Adobe)
  - OpenGL (Silicon Graphics)
  - DirectX (Microsoft)
  - Java3D (Sun)
- Mobile graphics
  - OpenGL ES
  - JSR-184

Graphics Hardware



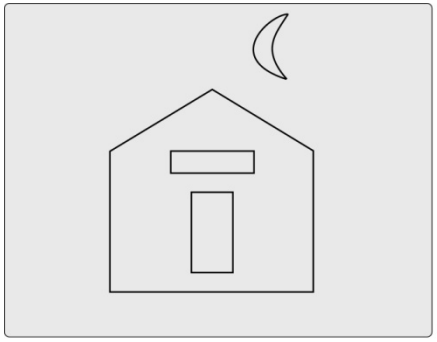
Input devices

Output device

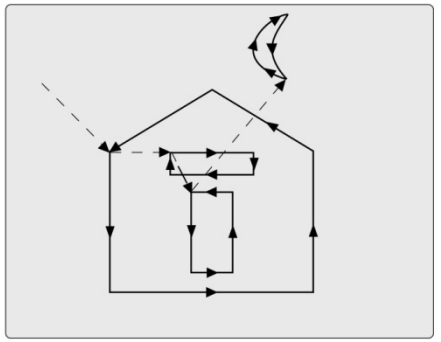
Image formed in frame buffer

Comparison of Display Systems

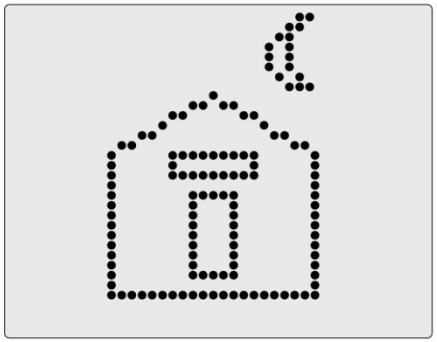
- Raster display system
  - developed in early seventies
  - frame buffer
  - scan conversion
  - aliasing
- Vector display system
  - until mid-eighties
  - display buffer
  - random scan
  - refresh cycle



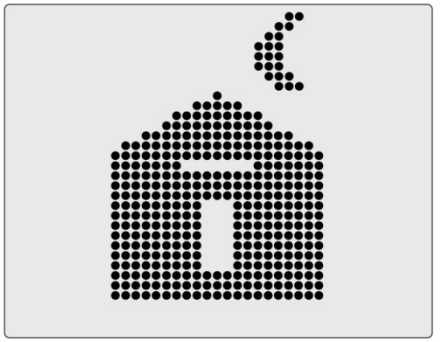
(a) Ideal line drawing



(b) Random scan



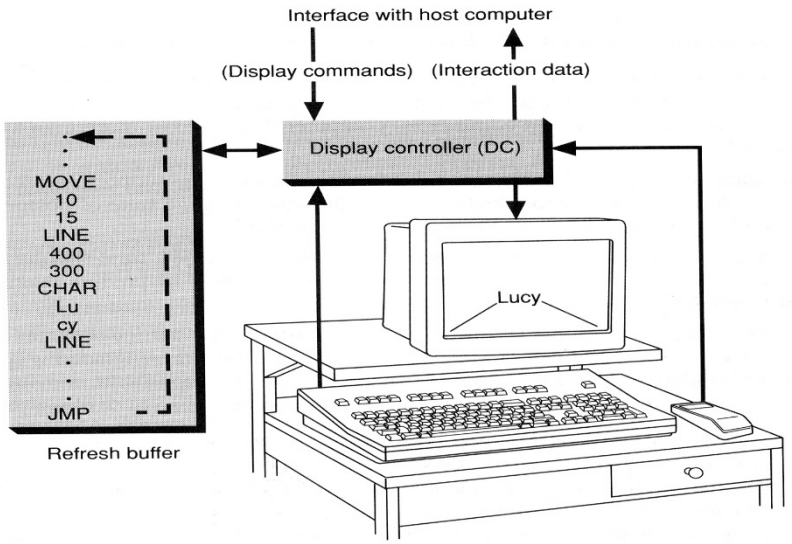
(c) Raster scan with outline primitives

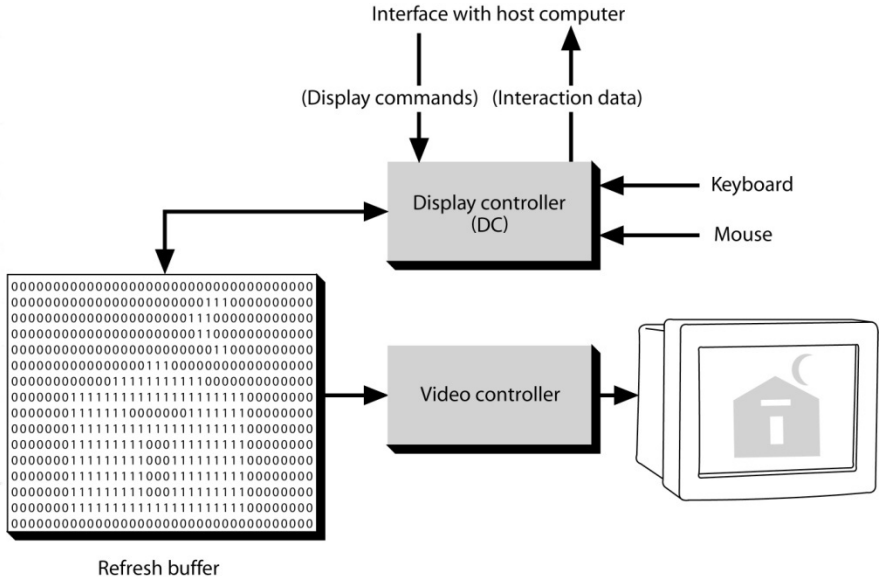


(d) Raster scan with filled primitives

Comparison of Display Systems (2)

- Raster display vs. Vector display





Research Goal of Graphics

- Design and implementation of graphics techniques and systems, which can help to produce interesting images and animations