

CS 312: Computer Graphics

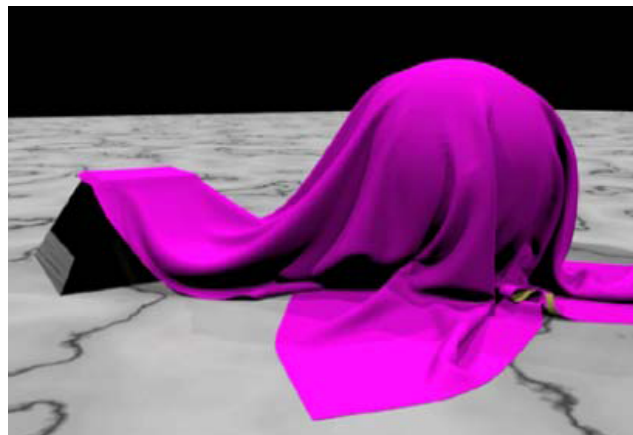
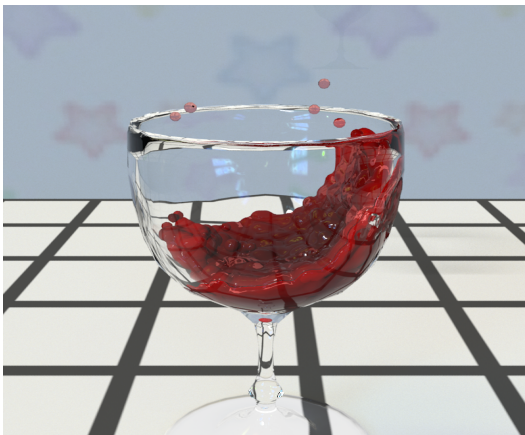
Introduction

What is Graphics?

- Making pictures with computers?
- Making pictures with math?



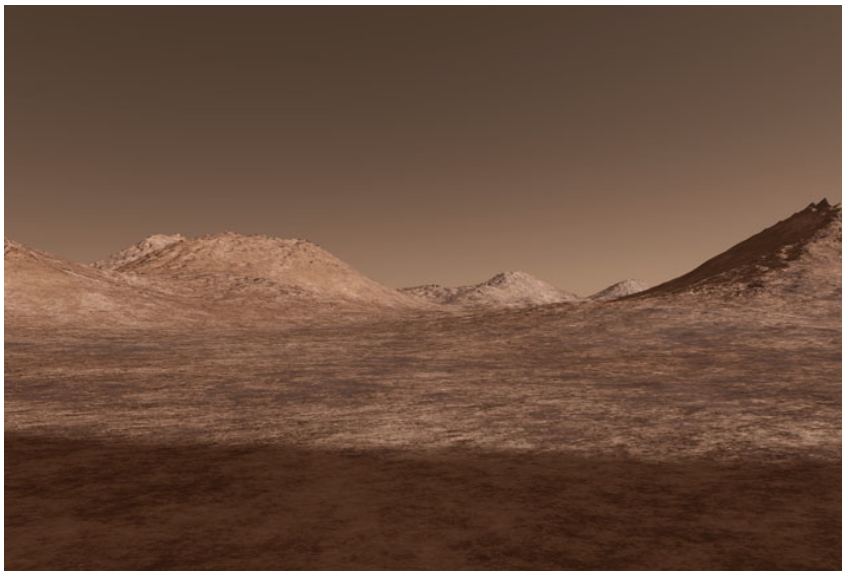
- Making pictures with physics?



Which ones are computer-generated?



Which ones are computer-generated?



Realistic vs. Artistic

Realistic/Photorealistic

- Look like real life
- Simulate physics
- Reasonable appearing approximation

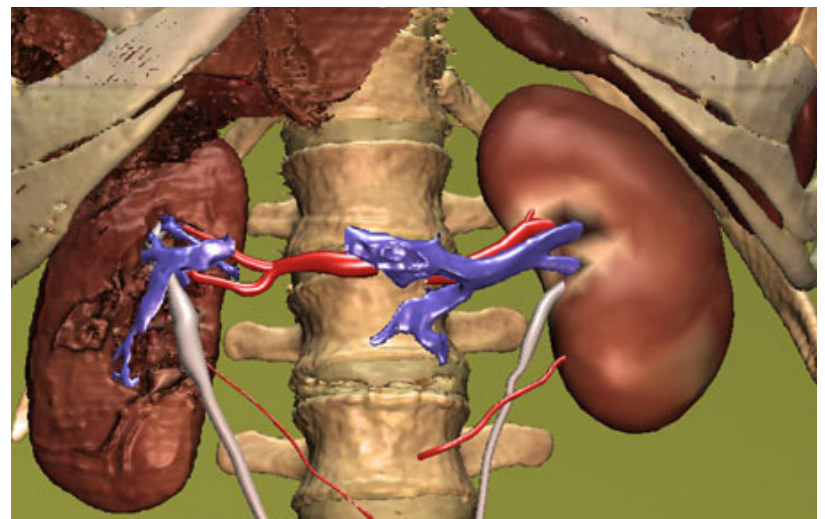
Artistic/Non-Photo-Realistic

- Look like what an artist might produce
- Model artist's process, physics
- Do what looks right (an art in itself)

Realistic: Norbert Kern, POV-Ray Hall of Fame Gallery



Non-photorealistic and Artistic Renderings



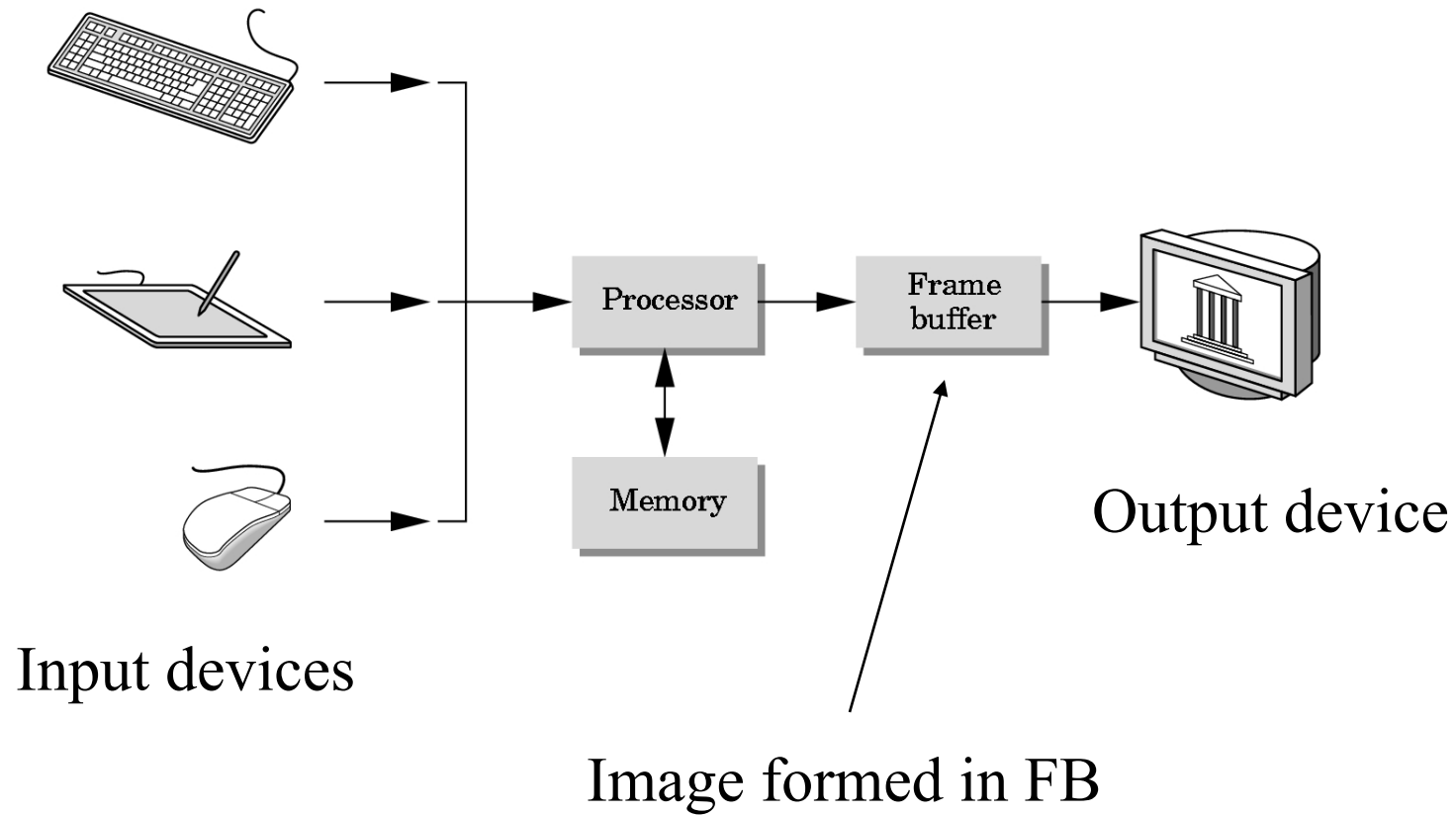
Real-time vs. Off-line

- Real-time/interactive
 - 10–60 frames per second
 - Games, interfaces, visual simulation...
- Offline/production
 - Seconds to hours per frame
 - Movies, architectural lighting simulation, ...

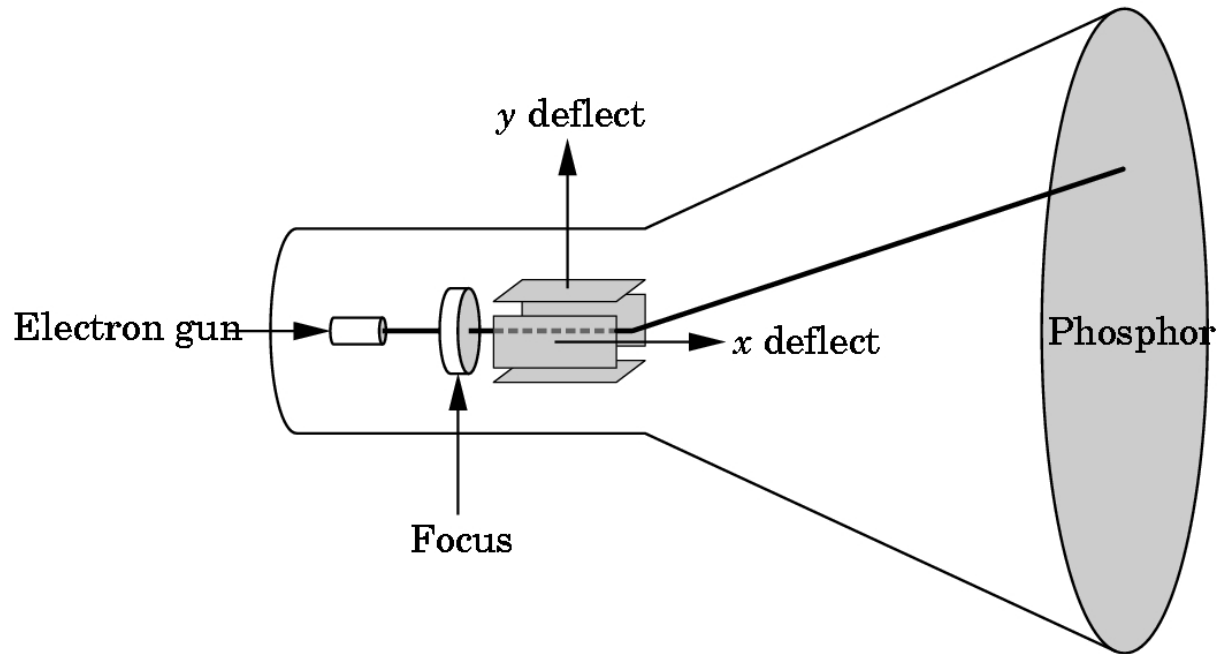


The Illustrated Brief History of Computer Graphics

Basic Graphics System



CRT



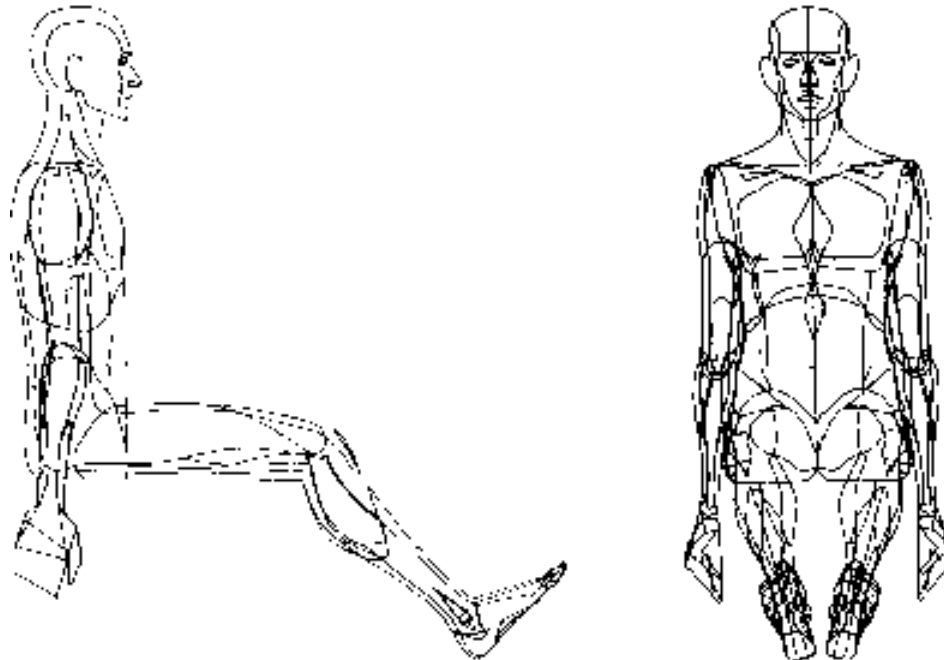
Can be used either as a line-drawing device (calligraphic) or to display contents of frame buffer (raster mode)

Display hardware

- vector displays
 - 1963 – modified oscilloscope
 - 1974 – Evans and Sutherland Picture System
- raster displays
 - 1975 – Evans and Sutherland frame buffer
 - 1980s – cheap frame buffers → bit-mapped PCs
 - 1990s – liquid-crystal displays → laptops
 - 2000s – micro-mirror projectors → digital cinema
- other
 - stereo, head-mounted displays
 - autostereoscopic displays
 - tactile, haptic, sound

William Fetter (1960)

- William Fetter of Boeing coins the term "computer graphics" for his human factors cockpit drawings



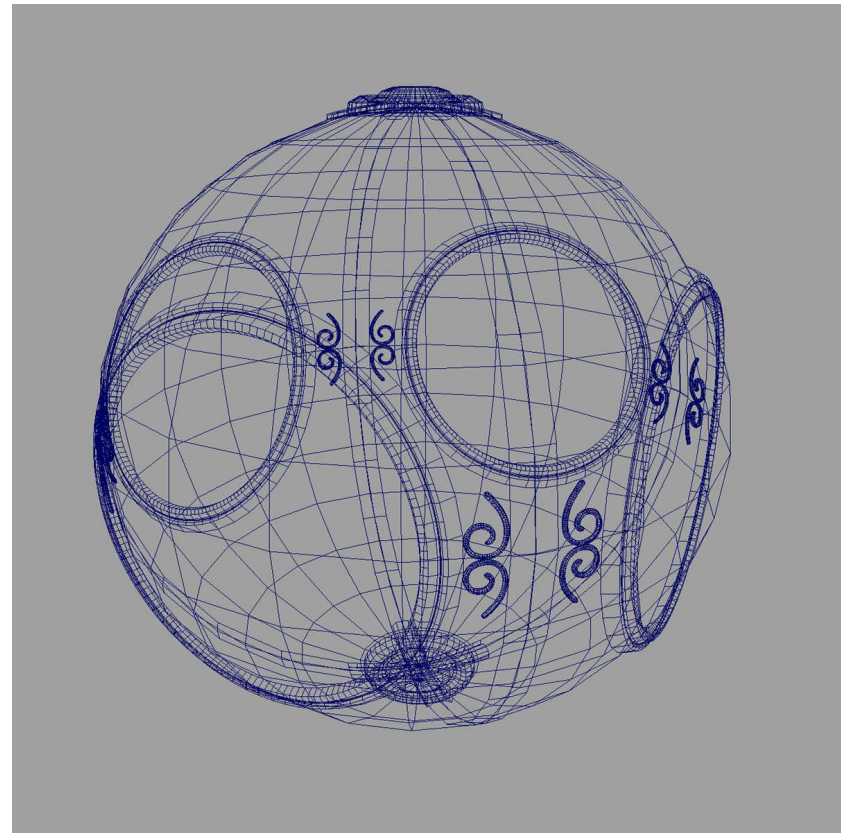
Computer Graphics: 1950-1960

- Computer graphics goes back to the earliest days of computing
 - Strip charts
 - Pen plotters
 - Simple displays using A/D converters to go from computer to calligraphic CRT
- Cost of refresh for CRT too high
 - Computers slow, expensive, unreliable

Computer Graphics: 1960-1970

- *Wireframe* graphics
 - Draw only lines
- Project Sketchpad
- Display Processors
- Storage tube

wireframe representation
of sun object



Ivan Sutherland (1963) - SKETCHPAD



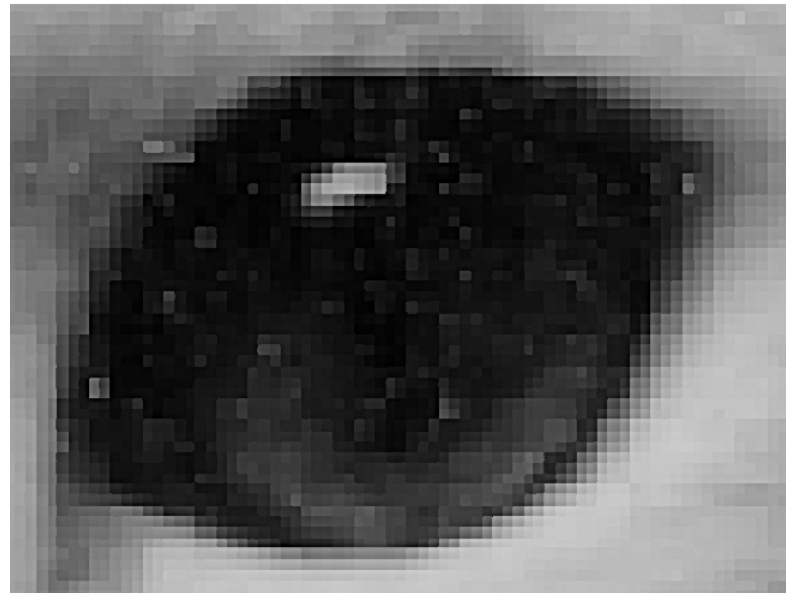
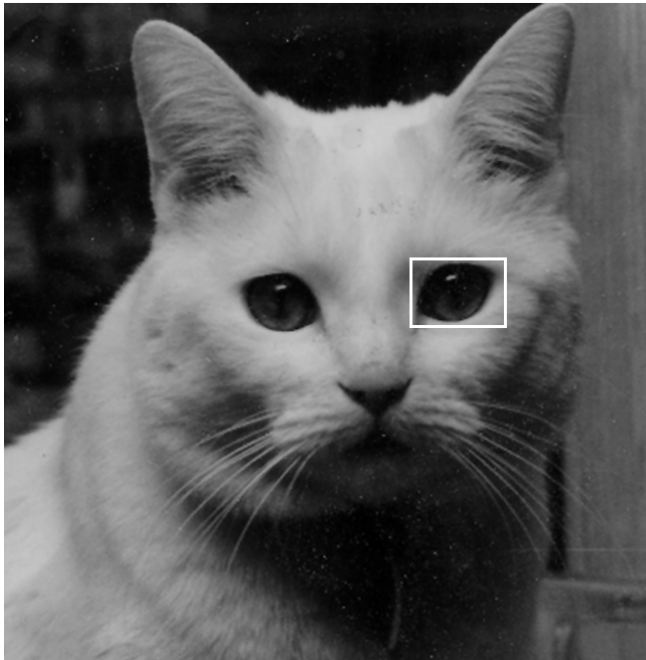
- Man-machine graphical communication system, MIT
- Pop-up menus
- Constraint-based drawing

Computer Graphics: 1970-1980

- Raster Graphics
- Beginning of graphics standards
 - IFIPS
 - GKS: European effort
 - Becomes ISO 2D standard
 - Core: North American effort
 - 3D but fails to become ISO standard
- Workstations and PCs

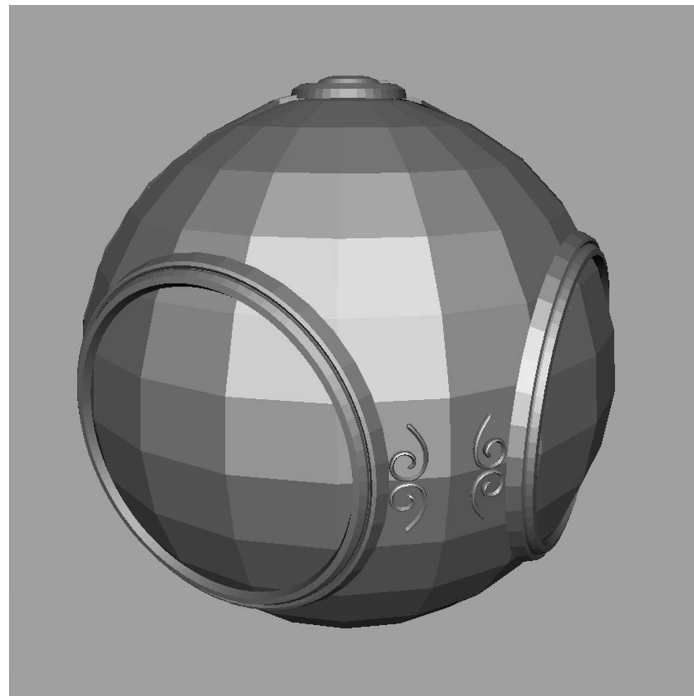
Raster Graphics

- Image produced as an array (the *raster*) of picture elements (*pixels*) in the *frame buffer*



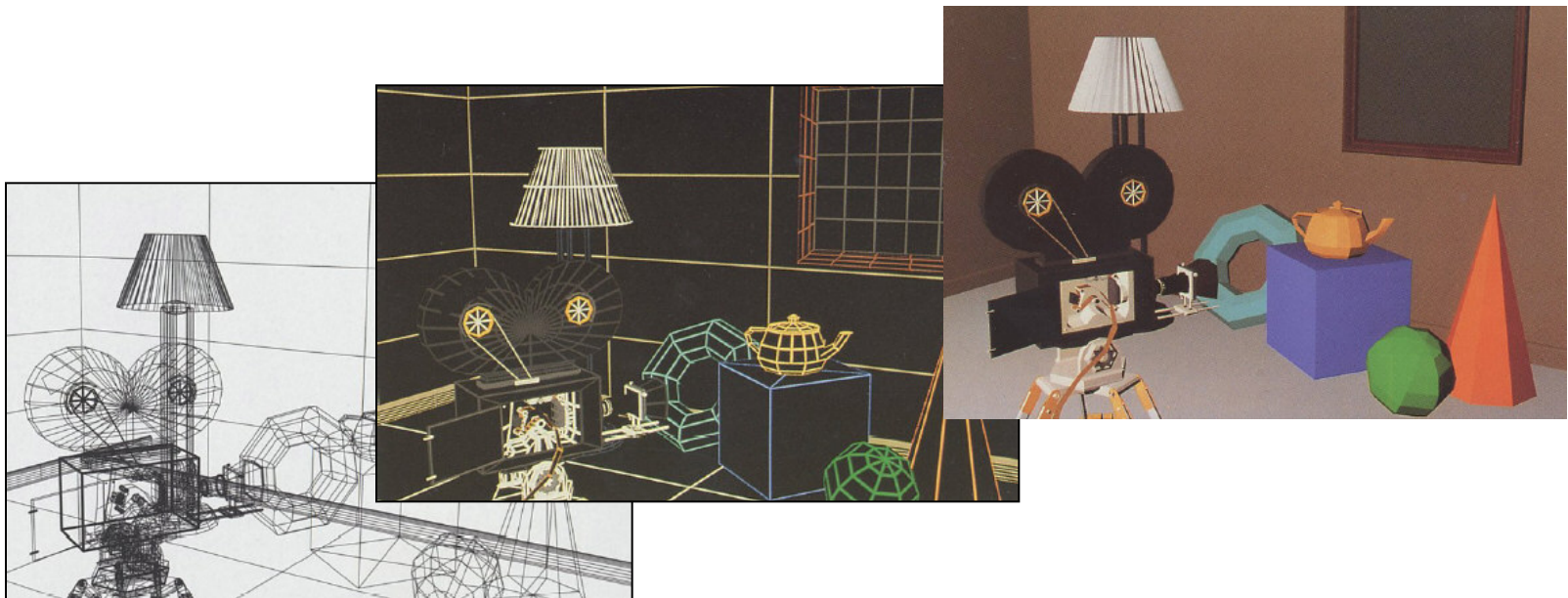
Raster Graphics

- Allows us to go from lines and wire frame images to filled polygons



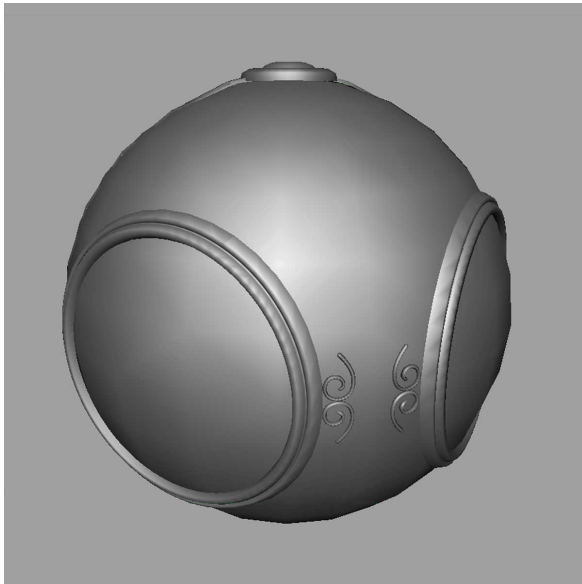
Rendering

- 1960s and 1970s - the visibility problem
 - Roberts (1963), Appel (1967) - hidden-line algorithms
 - Warnock (1968), Watkins (1968) - hidden-surface algorithms
 - Catmull (1974) – z-buffer: depth sorting



Computer Graphics: 1980-1990

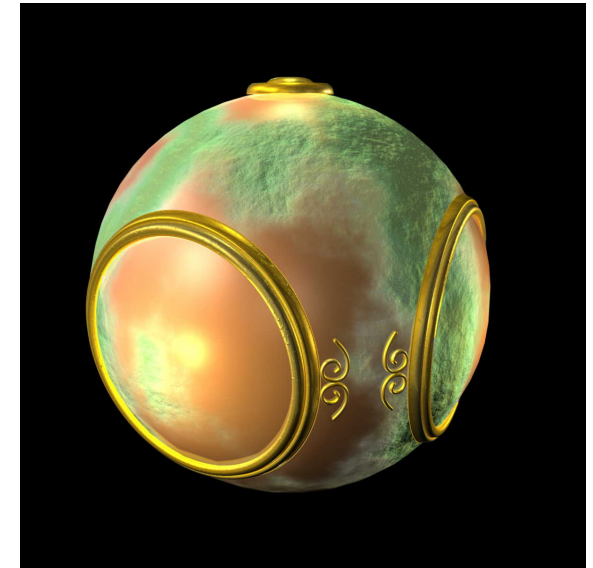
Realism comes to computer graphics



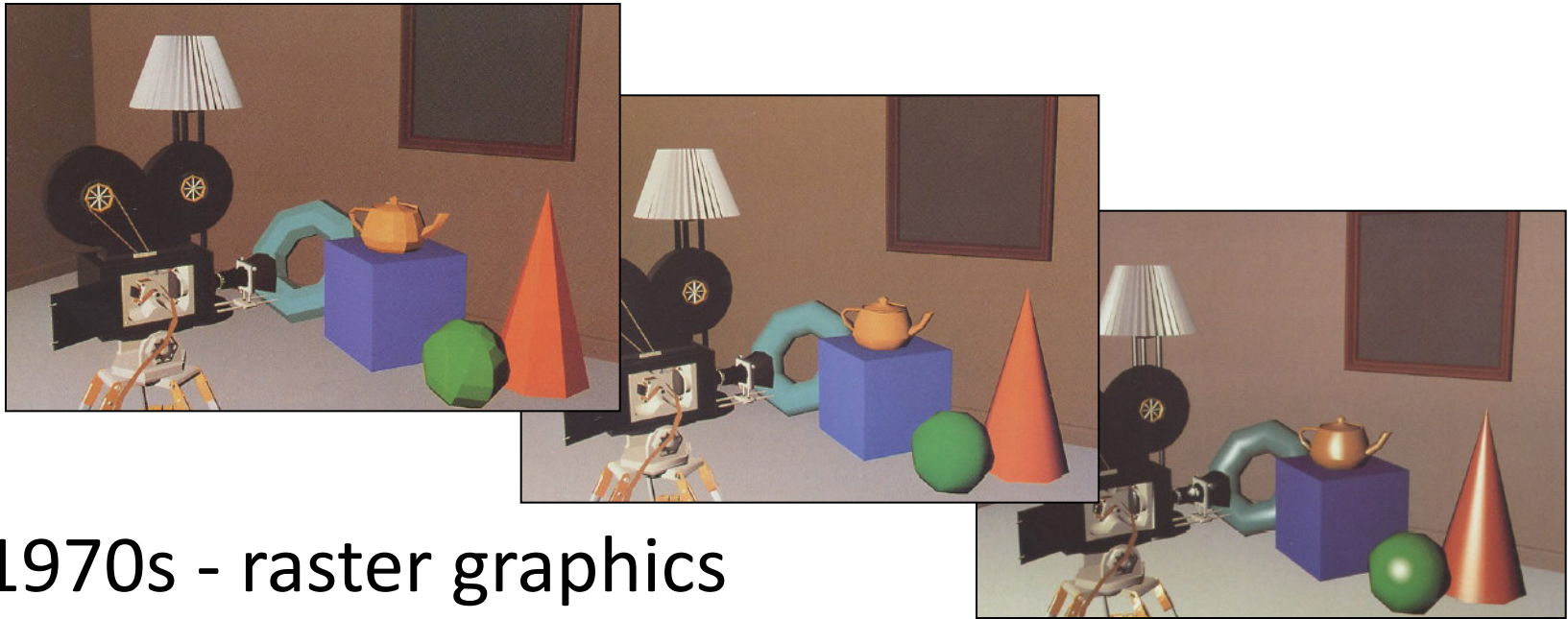
smooth shading



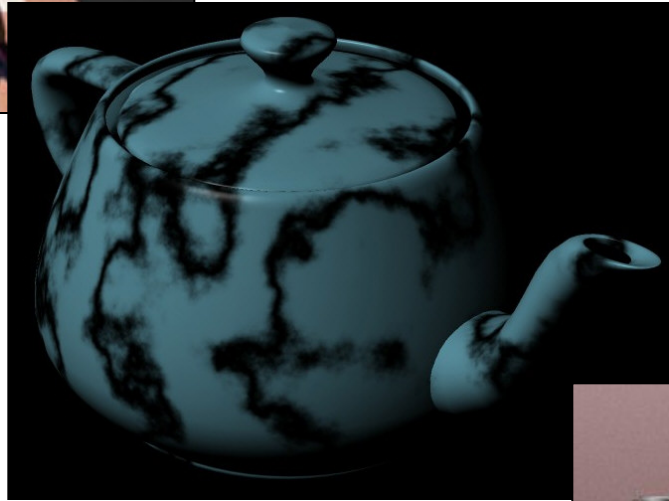
environmental
mapping



bump mapping

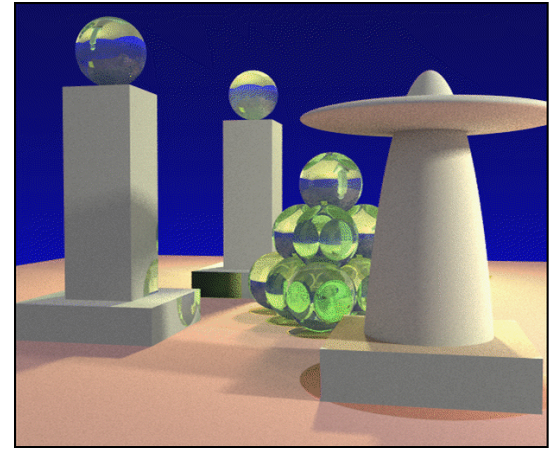
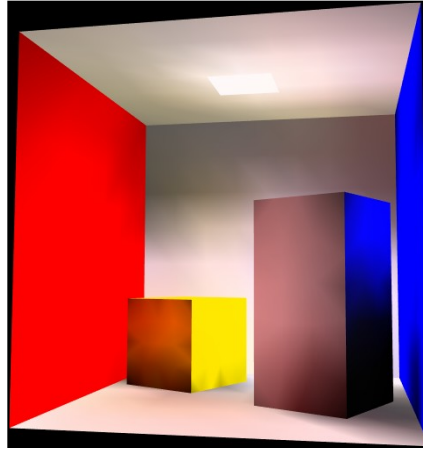
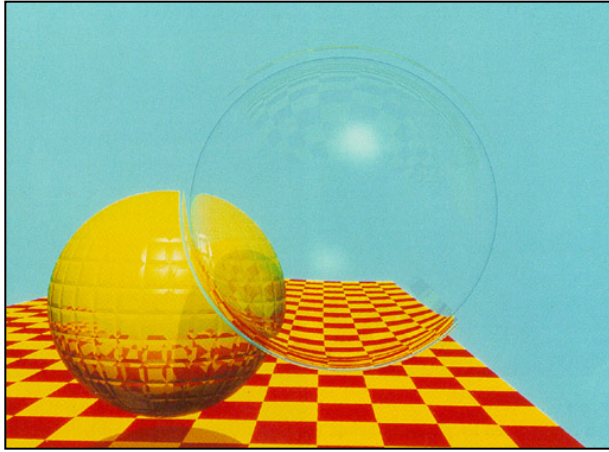


- 1970s - raster graphics
 - Gouraud (1971) - diffuse lighting – continuous shading of curved surfaces
 - Phong (1975) - specular lighting
 - Blinn (1976) – environment mapping, texture
 - Catmull (1974) - Z-buffer hidden-surface algorithm
 - Crow (1977) - anti-aliasing

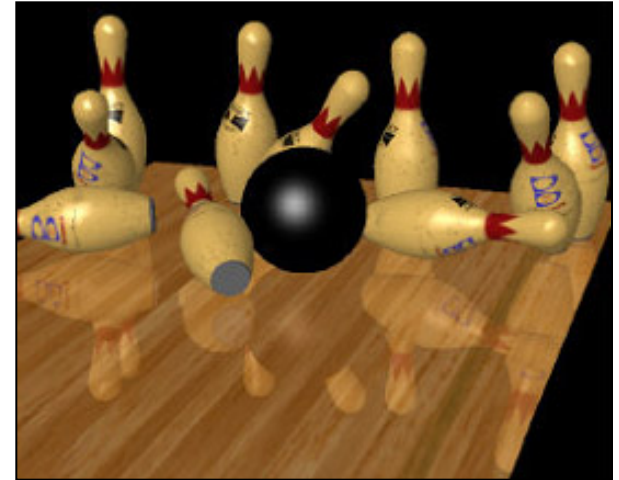


Computer Graphics: 1980-1990

- Special purpose hardware
 - Silicon Graphics geometry engine
 - VLSI implementation of graphics pipeline
- Industry-based standards
 - PHIGS
 - RenderMan
- Networked graphics: X Window System
- Human-Computer Interface (HCI)



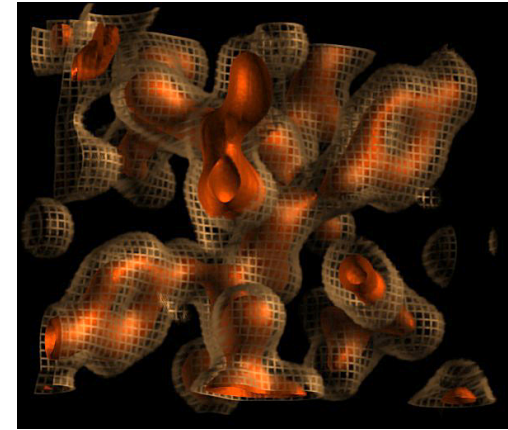
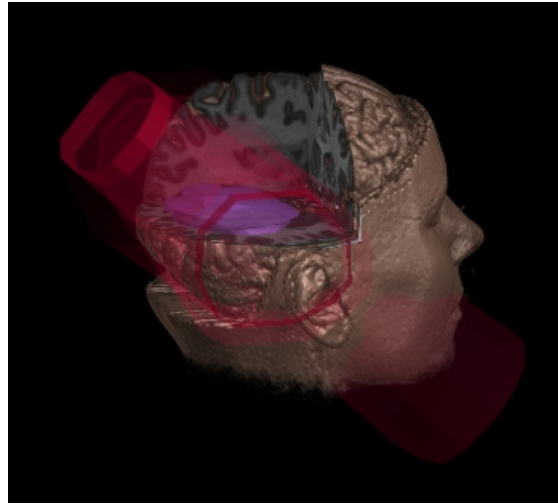
- Early 1980s - global illumination
 - Whitted (1980) - ray tracing
 - Goral, Torrance et al. (1984), Cohen (1985) - radiosity
 - Kajiya (1986) – the rendering equation



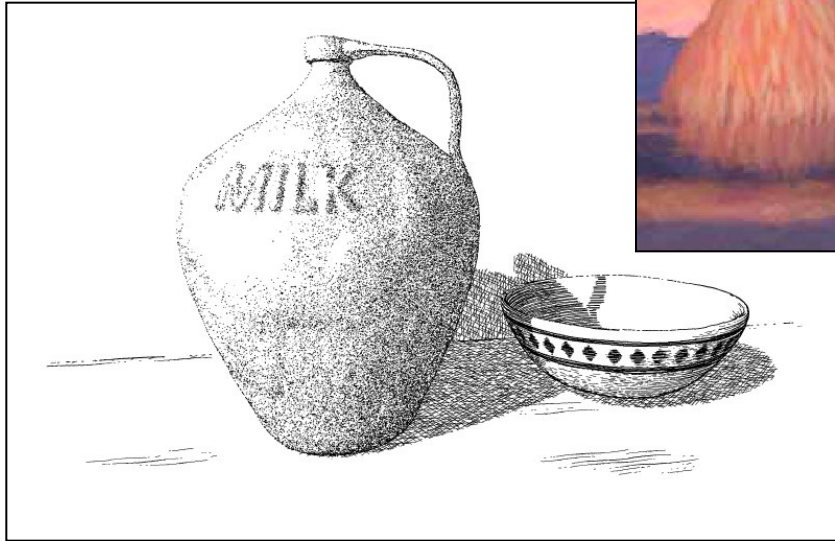
- Late 1980s - photorealism
 - Cook (1984) - shade trees
 - Perlin (1985) – noise function for realistic textures of marble, water waves, fire etc
 - Pixar (1990) - RenderMan

Computer Graphics: 1990-2000

- OpenGL API
- Completely computer-generated feature-length movies (Toy Story) are successful
- New hardware capabilities
 - Texture mapping
 - Blending
 - Accumulation, stencil buffers



- early 1990s - non-photorealistic rendering
 - Drebin et al. (1988), Levoy (1988) - volume rendering
 - Haeberli (1990) - impressionistic paint programs
 - Salesin et al. (1994-) - automatic pen-and-ink illustration
 - Meier (1996) - painterly rendering



Computer Graphics: 2000-

- Photorealism
- Graphics cards for PCs dominate market
 - Nvidia, ATI, 3DLabs
- Game boxes and game players determine direction of market
- Computer graphics routine in movie industry:
Maya, Lightwave

The graphics pipeline



Modeling

- Polygonal meshes
- Constructive Solid Geometry
- Curved (spline) surfaces
- Implicit surfaces
- Subdivision/iterative methods
- Particle systems
- Volumes (voxels, oct-tree)

Animation

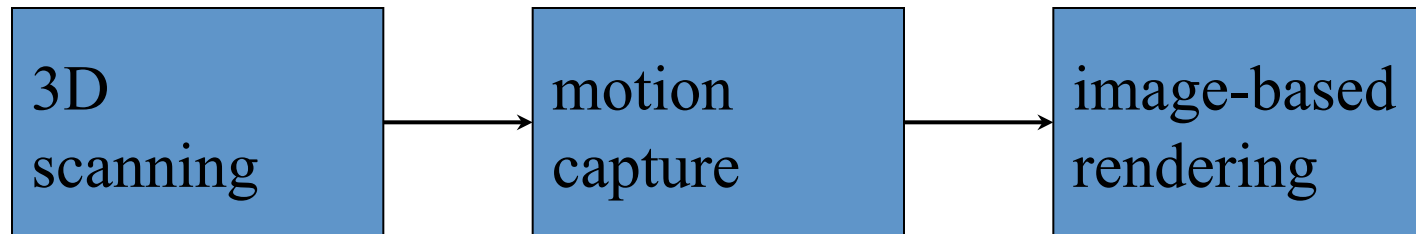
- Scripted
- Key-frame interpolation
- Inverse kinematics
- Dynamics

The graphics pipeline

The traditional pipeline



The new pipeline?



- late 1990s - image-based rendering
 - Chen and Williams (1993) - view interpolation
 - McMillan and Bishop (1995) - plenoptic modeling
 - Levoy and Hanrahan (1996) - light field rendering

Image-based Lighting

- negative film -> 130:1 (7 stops)
- paper prints -> 46:1
- Debevec, 97 -> 250,000:1 (16 stops)

