CE 411 - Computer Graphics
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what is this course really about?

Not!

Paint and Imaging packages (Adobe Photoshop)
CAD packages (AutoCAD)
Rendering packages (Lightscape)
Modeling packages (3D Studio MAX)
Animation packages (Digimation)
Graphics Modeling and Languages (RenderMan)

We will cover...

Graphics programming algorithms
Graphics data structures
Color and human vision
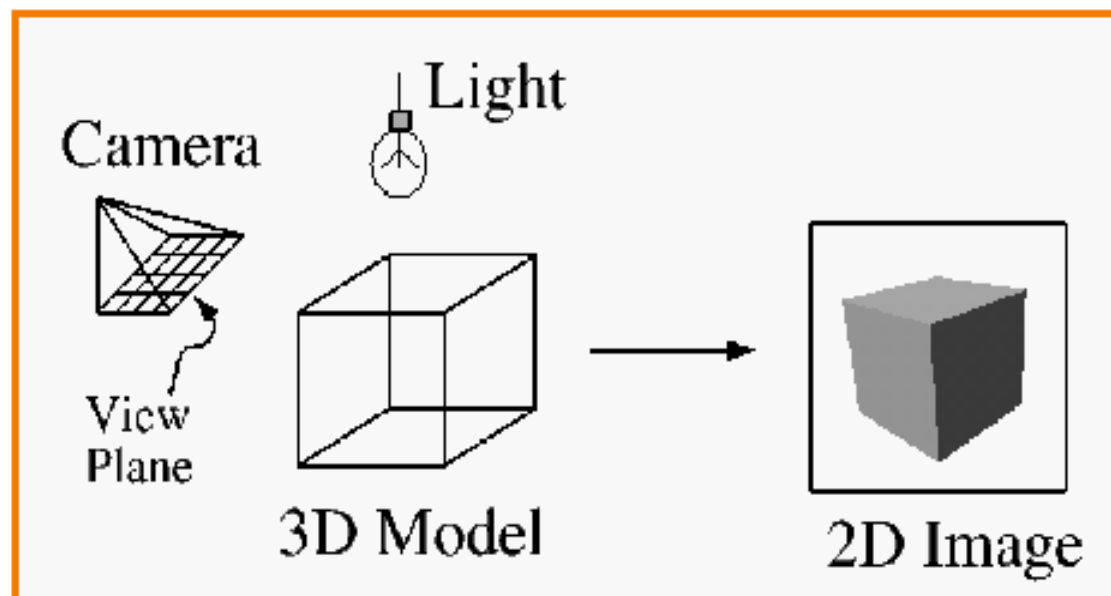Graphical interface design and programming
Applied geometry and modeling
Applied numerical computing

Introduction

- What is computer graphics?
  - Imaging = *representing 2D images*
  - Modeling = *representing 3D objects*
  - Rendering = *constructing 2D images from 3D models*
  - Animation = *simulating changes over time*

Light

Camera

View
Plane

3D Model

2D Image

Applications

- Entertainment
- Computer-aided design
- Scientific visualization
- Training
- Education
- E-commerce
- Computer art

Applications

→ **Entertainment**

- Computer-aided design

- Scientific visualization

- Training

- Education

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Jurasic Park
(Industrial, Light, & Magic)

Geri's Game
(Pixar Animation Studios)

Quake
(Id Software)

Computer Graphics is about **Movies**!

The entertainment industry plays many other important roles in the field of computer graphics.

If you can imagine it, it can be done with computer graphics. Obviously, Hollywood has caught on to this. Each summer, we are amazed by state-of-the-art special effects. More and more of these images exist only within the memory of a computer. There seems to be no end in sight for this trend. But we're not just talking about big budget mega-productions. There are music videos, and spinning logos on the 6 o'clock news. Computer graphics is now as much a part of the entertainment industry as stunt men and makeup

Applications

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- → **Computer-aided design**
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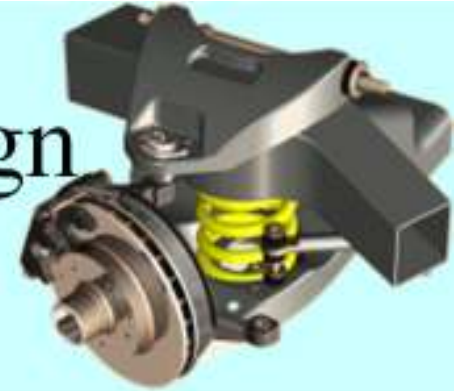
Los Angeles Airport
(Bill Jepson, UCLA)

Gear Shaft Design
(Intergraph Corporation)

Boeing 777 Airplane
(Boeing Corporation)

Computer Aided Design

Computer graphics has had a dramatic impact on the design process. Today, most mechanical and electronic designs are executed entirely on computer. Increasingly, architectural and product designs are also migrating to the computer. Automated tools are also available that verify tolerances and design constraints directly from CAD designs. CAD designs also play a key role in a wide range of processes from the design of tooling fixtures to manufacturing.

CAD has had the follow impact on computer graphics.

1. Drives the high-end of the HW market
2. Integration of computing and display resources
3. Reduced design cycles (faster systems sooner)

Applications

- Entertainment

- Computer-aided design

➜ **Scientific visualization**

- Training

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Airflow Inside a Thunderstorm
*(Bob Wilhelmson,
University of Illinois at Urbana-Champaign)*

Apo A-1
*(Theoretical Biophysics Group,
University of Illinois at Urbana-Champaign)*

Visible Human
*(National Library of Medicine)*

Scientific Visualization

Computer graphics makes vast quantities of data accessible. Numerical simulations frequently produce millions of data values. Similarly, satellite-based sensors amass data at rates beyond our abilities to interpret them by any other means than visually. Mathematicians use computer graphics to explore abstract and high-dimensional functions and spaces. Physicists can use computer graphics to transcend the limits of scale. With it they can explore both microscopic and macroscopic worlds.
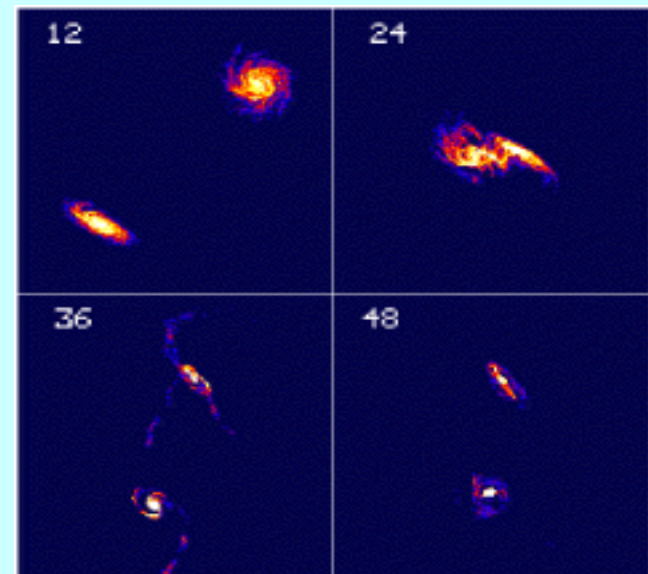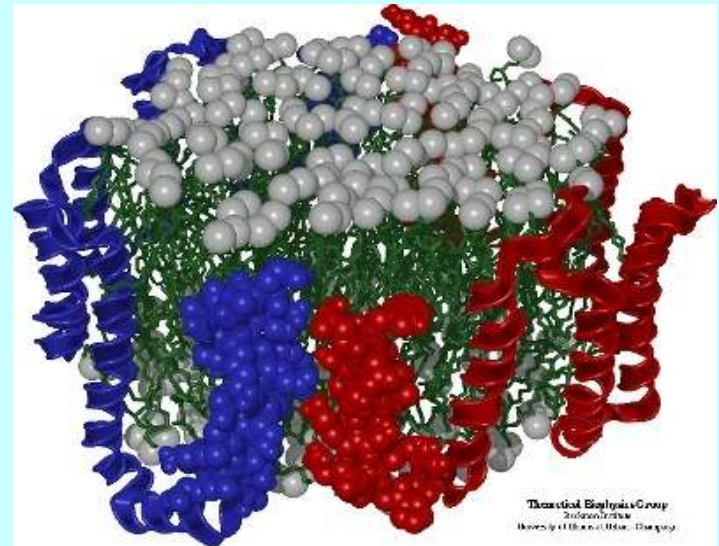
Graphical User Interfaces (GUIs)

Computer graphics is an integral part of every day computing. Nowhere is this fact more evident than the modern computer interface design. Graphical elements such as windows, cursors, menus, and icons are so common place it is difficult to imagine computing without them. Once graphics programming was considered a specialty. Today, nearly all professional programmers must have an understanding of graphics in order to accept input and present output to users.
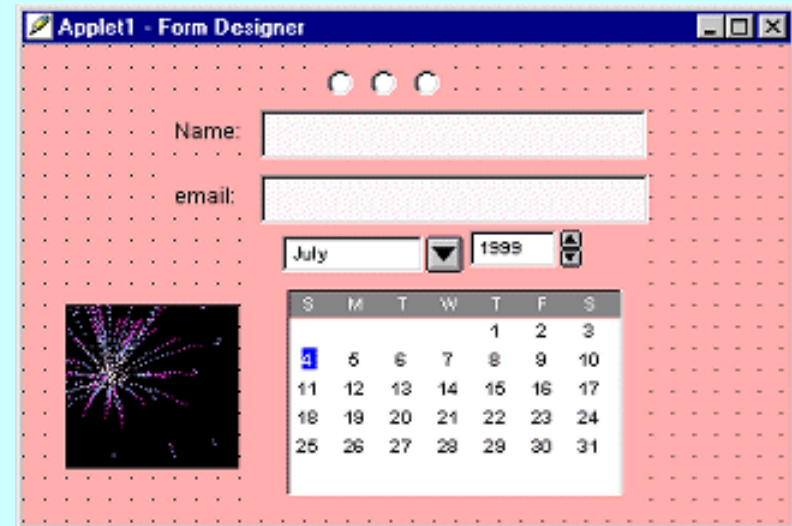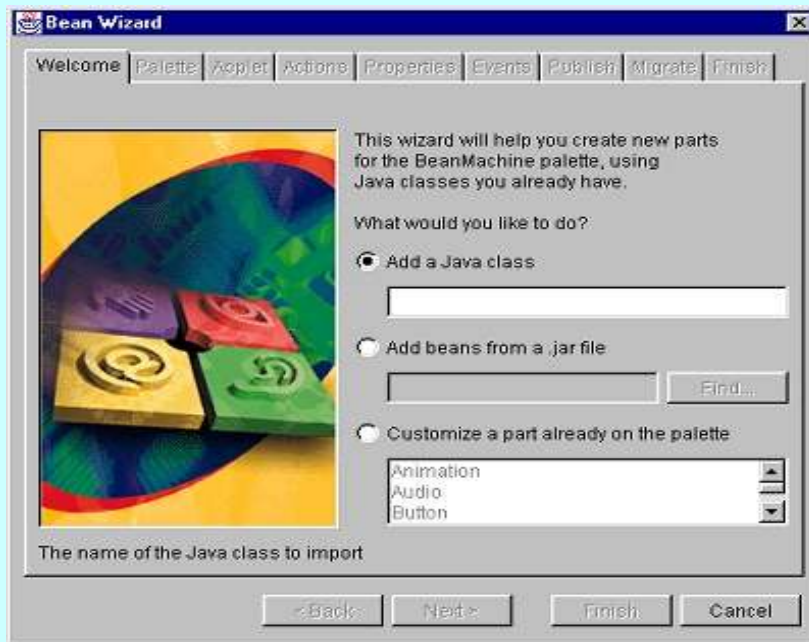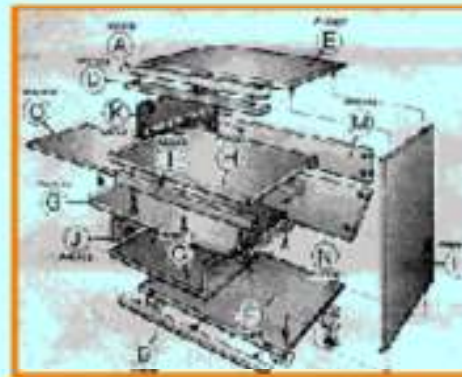
Applications

- Entertainment

- Computer-aided design

- Scientific visualization

→ **Training**

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Driving Simulation
(Evans & Sutherland)

Desk Assembly
(Silicon Graphics, Inc.)

Flight Simulation
(NASA)

Games are okay here!

Games are an important driving force in computer graphics. In this class we are going to talk about games. We'll discuss on how they work. If anyone asks, tell them you're doing science.

How the game's industry impacts computer graphics

1. Focus on interactivity

2. Cost-effective solutions

3. Avoiding computation and other tricks

4. Games drive the baseline

Applications

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→ **Education**
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Forum of Trajan
(Bill Jepson, UCLA)

Human Skeleton
(SGI)

Medical Imaging

There are few endeavors more noble than the preservation of life. Today, it can honestly be said that computer graphics plays an significant role in saving lives. The range of application spans from tools for teaching and diagnosis, all the way to treatment. Computer graphics is *tool* in medical applications rather than an a mere artifact. No cheating or tricks allowed.

How medical applications influence computer graphics technology

1. New data representations and modalities
2. Drive issues of precision and correctness
3. Focus on presentation and interpretation of data
4. Construction of models from acquired data

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Interactive Kitchen Planner
(Matsushita)

Virtual Phone Store
(Lucent Technologies)

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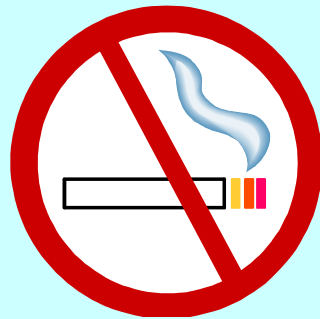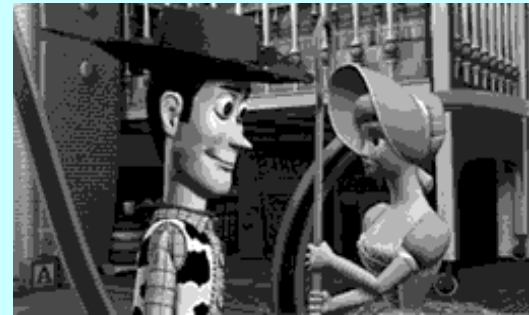http://www.siggraph.org/artdesign/

Blair Arch
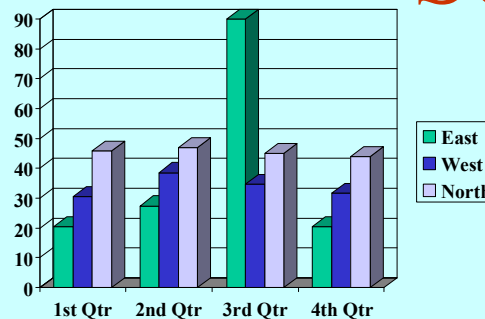(Marissa Range & Adam Finkelstein,
Princeton University)c

Examples of Computer Graphics
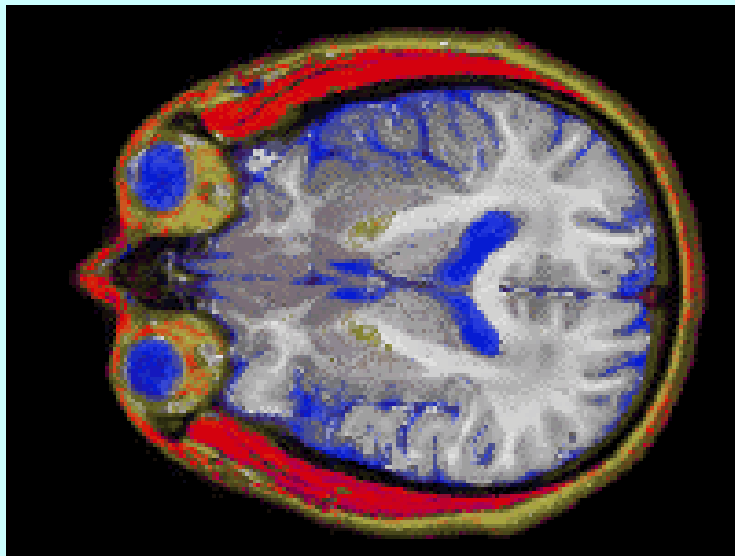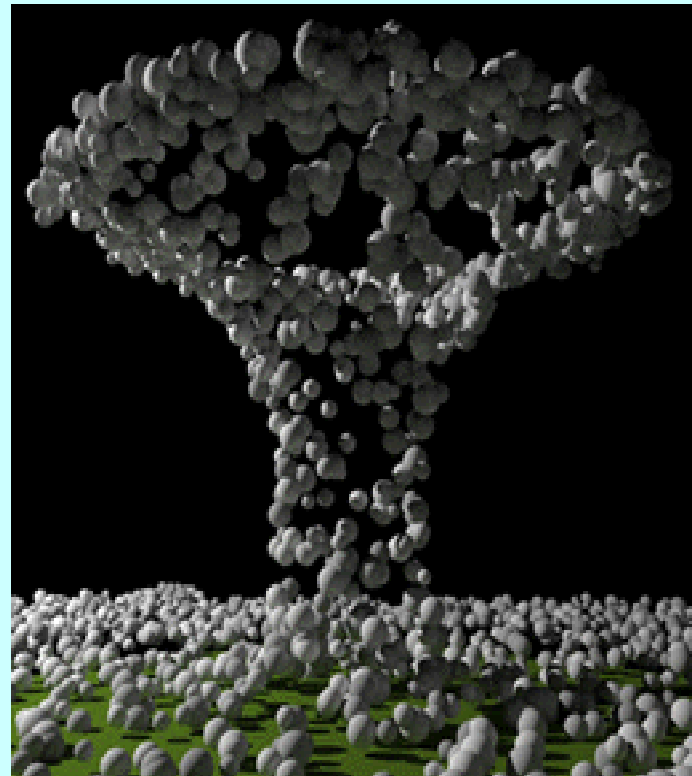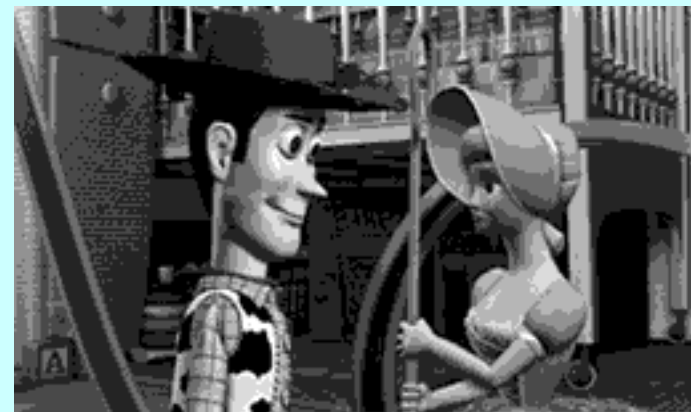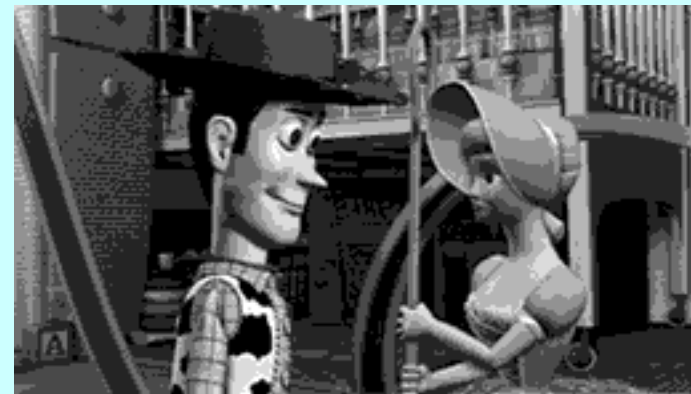
Icons & Symbols

Rendered Scenes

Images

Charts & Graphs

More _**Cool**_ Pictures

Examples of scientific visualization

More _**Cool**_ Pictures

Video!

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 personal computers
  - 1990s – liquid-crystal displays → laptops
  - 2000s – micro-mirror projectors → digital cinema
- other
  - stereo, head-mounted displays
  - tactile, haptic, sound

The graphics pipeline

Modeling

- polygons
- constructive solid geometry
- parametric surfaces
- implicit surfaces
- volumes

Animation

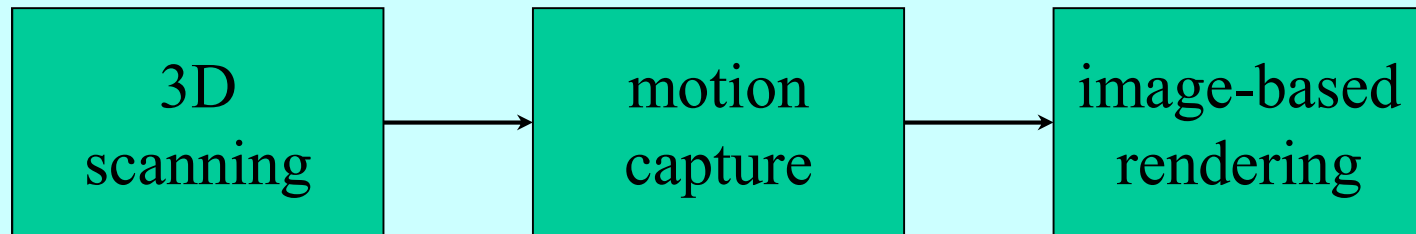- scripted
- key-frame interpolation
- inverse kinematics
- dynamics (F=ma, F=ku)

The graphics pipeline

the traditional pipeline

modeling	→ animation	→ rendering

the new pipeline?

3D scanning	→ motion capture	→ image-based rendering

Vector Displays

• Oscilloscopes were some of the 1st computer displays

• Computation results used to drive the vertical and horizontal axis (X-Y)

• Used mostly for line drawings

• Called *vector*, *calligraphic* or affectionately *stroker* displays

Raster Displays

• TV boomed in the 50s and early 60s (they got cheap)

• B/W TVs are basically oscilloscopes (with a hardwired scan pattern)

• Entire screen painted 30 times/sec

• Screen is traversed 60 times/sec

• Even/Odd lines on alternate scans (called fields)

• Smooth motion on dynamic scenes

• High Resolution on static scenes

• Optimize bandwidth

Raster Scan Pattern of Interlaced Display

Line 1
Line 2
Line 3
Line 4
Line 5
Line 6
Line 7
Line 8
Line 9
Line 10
Line 11
Line 12
Line 13
Line 14
Line 15
Line 16
Line 17
Line 18
Line 19

Line 521
Line 522
Line 523
Line 524
Line 525
Line 526