# Computer Graphics

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Princeton University

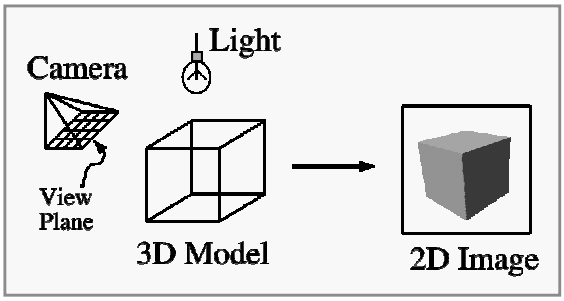
C0S 426, Fall 2000

## Overview

- Introduction
  - What is computer graphics?
- Applications
  - What is it good for?
- Syllabus
  - What will I learn in this course?
- Coursework
  - How much work will there be?
- Examples

## 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*

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## Applications

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

## Applications

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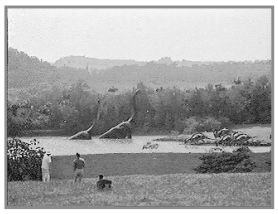
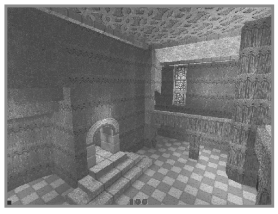


Jurasic Park
*(Industrial, Light, & Magic)*

Geri's Game
*(Pixar Animation Studios)*



Quake
*(Id Software)*

## Applications

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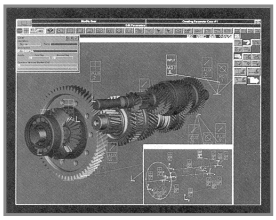
Los Angeles Airport
*(Bill Jepson, UCLA)*



Gear Shaft Design
*(Intergraph Corporation)*

Boeing 777 Airplane
*(Boeing Corporation)*

## Applications

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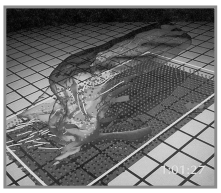


Airflow Inside a Thunderstorm
*(Bob Wilhelmson,*
*University of Illinois at Urbana-Champaign)*

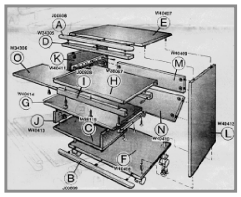
Apo A-1
*(Theoretical Biophysics Group,*
*University of Illinois at Urbana-Champaign)*

Visible Human
*(National Library of Medicine)*

## Applications

Driving Simulation
*(Evans & Sutherland)*

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



Desk Assembly
*(Silicon Graphics, Inc.)*

Flight Simulation
*(NASA)*

## Applications

- Entertainment
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- Scientific visualization
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- **Education**
- E-commerce
- Computer art

Forum of Trajan
*(Bill Jepson, UCLA)*

Human Skeleton
*(SGI)*

## Applications



- Entertainment
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- **E-commerce**
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Interactive Kitchen Planner
*(Matsushita)*

Virtual Phone Store
*(Lucent Technologies)*

## Applications

- Entertainment
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- **Computer art**

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

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- » **Syllabus**
  - **What will I learn in this course?**
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  - How much work will there be?
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## Syllabus



I. Image processing

II. Rendering

III. Modeling

IV. Animation

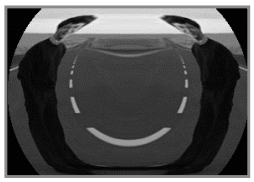
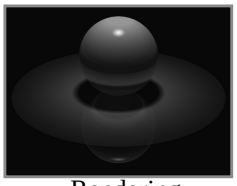
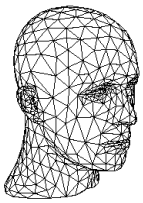


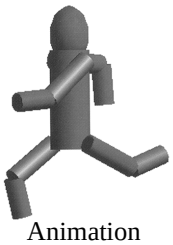
Image Processing
*(Rusty Coleman, CS426, Fall99)*



Rendering
*(Michael Bostock, CS426, Fall99)*



Modeling
*(Dennis Zorin, CalTech)*



Animation
*(Angel, Plate 1)*

## Part I: Image Processing

- Image Representation
  - Sampling
  - Reconstruction
  - Quantization & Aliasing
- Image Processing
  - Filtering
  - Warping
  - Morphing
  - Composition
- Raster Graphics
  - Display devices
  - Color models

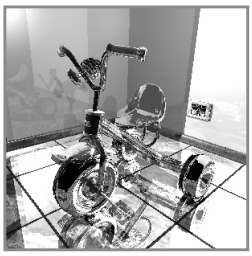
Image Composition
*(Michael Bostock, CS426, Fall99)*

Image Morphing
*(All students in CS 426, Fall98)*

## Part II: Rendering

- 3D Rendering Pipeline
  - Modeling transformations
  - Viewing transformations
  - Hidden surface removal
  - Illumination, shading, and textures
  - Scan conversion, clipping
  - Hierarchical scene graphics
  - OpenGL
- Global illumination
  - Ray tracing
  - Radiosity

OpenGL
*(Chi Zhang, CS 426, Fall99)*

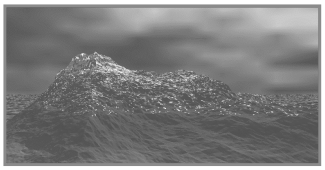


Ray Tracing
*(James Percy, CS 426, Fall99)*

## Part III: Modeling

- Representations of geometry
  - Curves: splines
  - Surfaces: meshes, splines, subdivision
  - Solids: voxels, CSG, BSP
- Procedural modeling
  - Sweeps
  - Fractals
  - Grammars

Shell
*(Douglas Turnbull, CS 426, Fall99)*

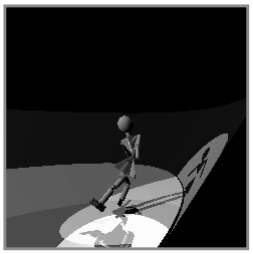


Scenery Designer
*(Dirk Balfanz, Igor Guskov, Sanjeev Kumar, & Rudro Samanta, CS426, Fall95)*

## Part IV: Animation

- Keyframing
  - Kinematics
  - Articulated figures
- Motion capture
  - Capture
  - Warping
- Dynamics
  - Physically-based simulations
  - Particle systems
- Behaviors
  - Planning, learning, etc.

Mr. Ed
*(Casey McTaggert, CS426, Fall99)*



Ice Queen
*(Mao Chen, Zaijin Guan, Zhiyan Liu, & Xiaohu Qie, CS426, Fall98)*

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## Quotes from Student Course Guide

- “Yes, if you haven't heard about it, it's called Death Graphics. You won't believe how much work you do for the course.”
- “This class is really a different experience from all other CS courses. If you have the guts, and you have the skills, and of course an interest in graphics, go for it. If you want to find out what a 'challenging’ semester means, go for it. Also, count this course as 2 courses when you are planning your schedule for the next semester.”

## Coursework

- "Midterm" Exam (25%)
  - Open book exam in class (on 11/21)
- Programming Assignments (10% each)
  - Assignment #1: Image Processing (due 9/29)
  - Assignment #2: Ray Tracing (due 10/13)
  - Assignment #3: 3D Rendering (due 10/27)
  - Assignment #4: Procedural Modeling (due 11/17)
  - Assignment #5: Animation (due 12/8)
- Final Project (20%)
  - Do something cool! (due Jan 01)
- Class Participation (5%)

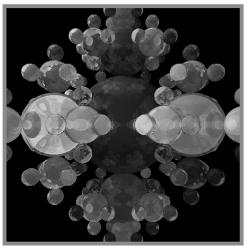
## Programming Assignments

- When?
  - Every two weeks
- Where?
  - MECA Labs
- How?
  - Windows 2000 (E417) or Unix (E423)
  - C and C++, OpenGL, GLUT
- What?
  - Basic feature lists
  - Extra credit lists
  - Art contest

Assignment 1 is already on-line!

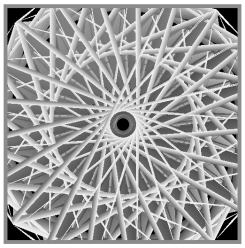
## Art Contest

- Everybody should submit entries!
  - 1 point for submitting
  - 2 points for winning



Cool Images
*(James Percy, CS 426, Fall99)*

Videos
*(Terrance Liu, CS 426, Fall99)*



Bloopers
*(Kathleen Mulcahey, CS 426, Fall99)*

## Collaboration Policy

- Overview:
  - You must write your own code (no credit for other code)
  - You must reference your sources of any ideas/code
- It's OK to …
  - Talk with other students about ideas, approaches, etc.
  - Get ideas from information in books, web sites, etc.
  - Get "support" code from example programs
    - » But, you must reference your sources
- It's NOT OK to …
  - Share code with another student
  - Use ideas or code acquired from another sources without attribution

## Survival Guide

- Programming Assignments (50%)
  - Drop the class if you can't program
  - Get started on every assignment early
  - Plan on using multiple programming sessions
  - Review progress/plan with TA during each assignment
  - Take the time to understand what you are doing
- Midterm (25%)
  - Pay attention in class
  - Keep up with the readings
- Final Project (20%)
  - Choose something you like

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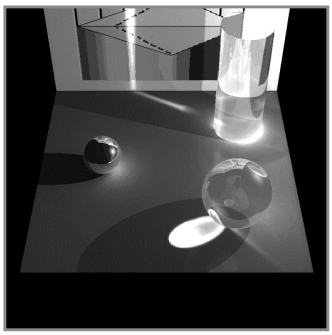
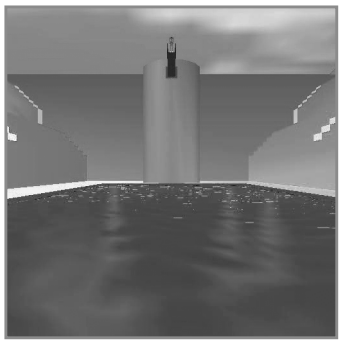
## Examples



Rendering Caustics
*(Michael Bostock, James Percy & Casey McTaggert, CS 426, Fall99)*



Diving Simulation
*(Ding Liu, Chi Zhang, & Ming Zhang, CS 426, Fall99)*

## Conclusion

- Course web page:
  - *http://www.cs.princeton.edu/courses/cs426/index.html*
- Precepts:
  - Wednesday at 8PM in CS102
- Web signup:
  - Follow directions on course web page
  - By next Wednesday (9/20)