גרפיקה ממוחשבת

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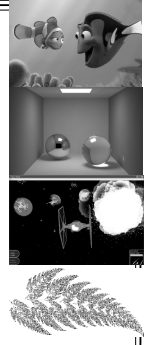
TA: Olga Sorkine

sorkine@tau.ac.il

Most slides are from Fredo Durand and Tom Funkhouser

Team

- Lecturer
  - Daniel Cohen-Or
  - Olga Sorkine
- TAs
  - Alon Lerner
  - Andrie Scharf, Tali Ironi
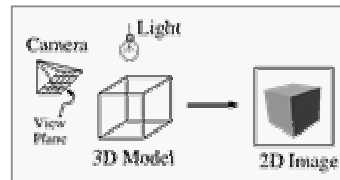

Overview

- 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*

Visual Sciences
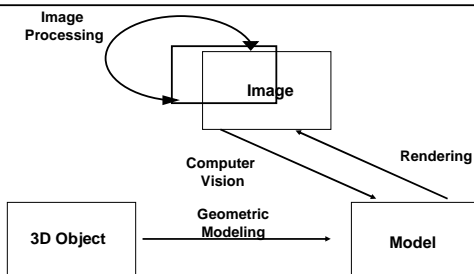
Image Processing

Image

Computer Vision

Rendering

3D Object

Geometric Modeling

Model

Applications

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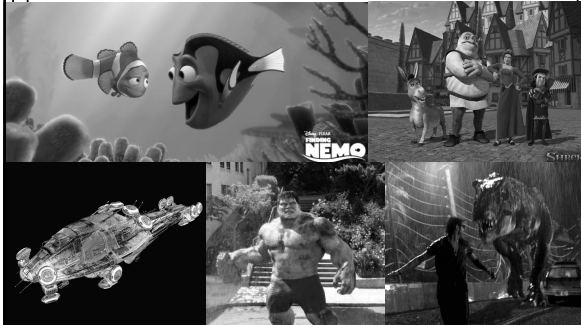- Education
- E-commerce
- Computer art

Jurasic Park
(Industrial, Light, & Magic)

Geri's Game
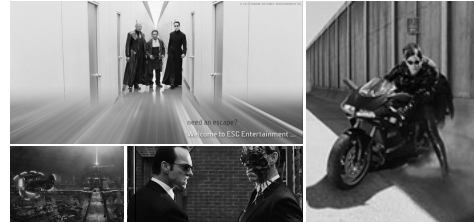*(Pixar Animation Studios)*

Quake
(Id Software)

Movies

Digression

- George Borshukov, vfx technology supervisor , ESC entertainment (The Matrix)

Luxo Jr

- Pixar Animation Studios, 1986
- Director: John Lasseter

Games

Simulation

Applications

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

Los Angeles Airport
(Bill Jepson, UCLA)

Gear Shaft Design
(Intergraph Corporation)

Boeing 777 Airplane
(Boeing Corporation)

CAD-CAM & design

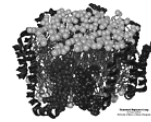## Virtual reality

Applications: Virtual Reality

Applications

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

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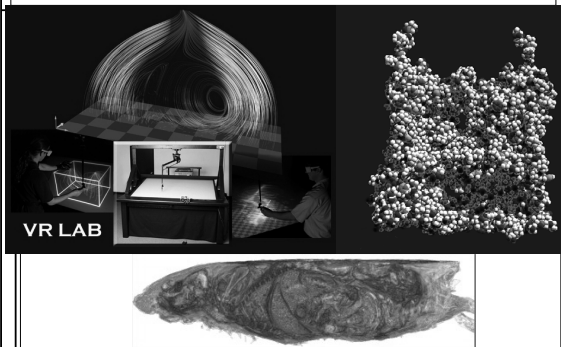*(Bob Wilhelmson,
University of Illinois at Urbana-Champaign)*

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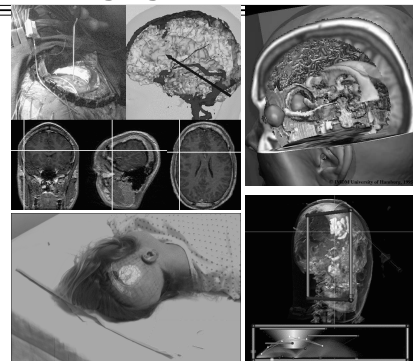University of Illinois at Urbana-Champaign)*

Visible Human
(National Library of Medicine)
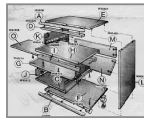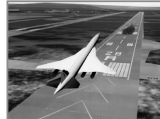
Visualization

VR LAB

Medical imaging

3

Applications

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

Driving Simulation
(Evans & Sutherland)

Desk Assembly
(Silicon Graphics, Inc.)

Flight Simulation
(NASA)

Applications

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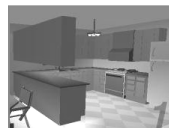- **Education**
- E-commerce
- Computer art

Forum of Trajan
(Bill Jepson, UCLA)

Human Skeleton
(SGI)

Applications

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

Interactive Kitchen Planner
(Matsushita)

TELE–CONFERENCING
Virtual Phone Store
(Lucent Technologies)

Applications

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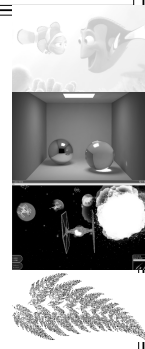- Education
- E-commerce
- **Computer art**

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

Applications

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

Questions?

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Syllabus (What will I learn in this course? And what not?)

I. Image processing

II. Rendering

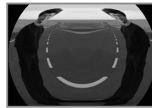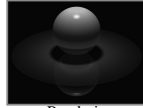III. Modeling

IV. OpenGL

V. Animation

Image Processing
(Rusty Coleman, CS426, Fall99)

Rendering
(Michael Bostock, CS426, Fall99)

Modeling
(Dennis Zorin, CalTech)

Animation
(Angel, Plate 1)

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)

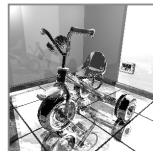
Rendering

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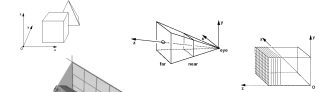 - Hierarchical scene graphics
  - OpenGL
- Global illumination
  - Ray tracing
  - Radiosity

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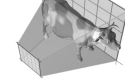*(Chi Zhang, CS 426, Fall99)*

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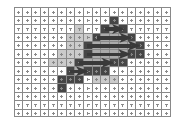*(James Percy, CS 426, Fall99)*

The Rendering Pipeline

- Transformations
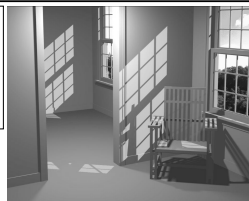
- Clipping

- Rasterization

- Visibility

Rendering
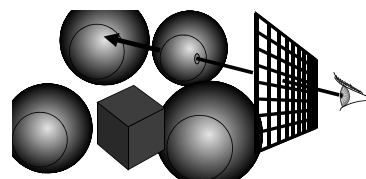
- Global illumination
  - Ray tracing
  - Radiosity

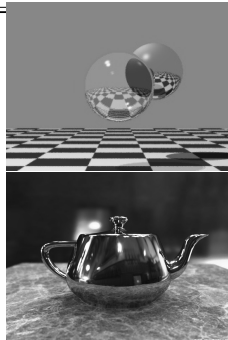---

Ray Casting

- For every pixel
  construct a ray from the eye
  - For every object in the scene
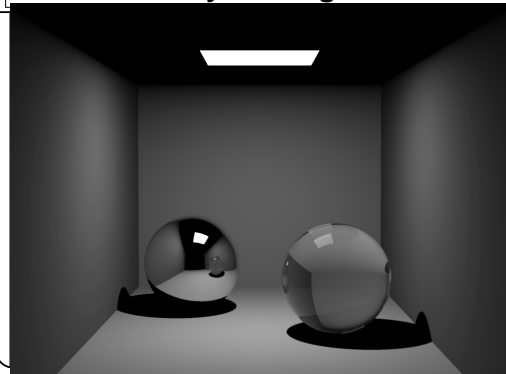   - Find intersection with the ray
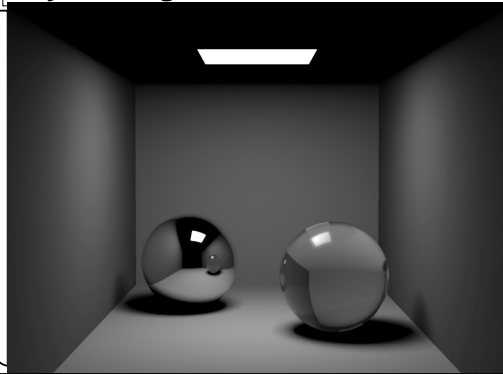   - Keep if closest

Ray Tracing

- Original Ray-traced image by Whitted

- Image computed using the Dali ray tracer by Henrik Wann Jensen
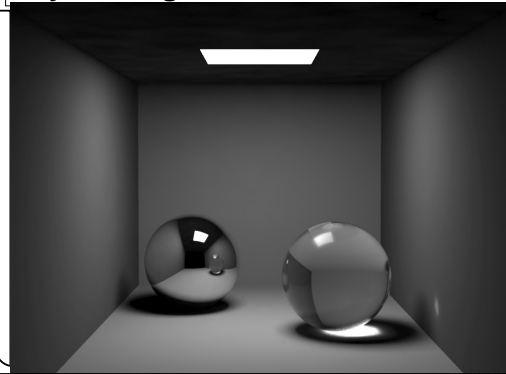
- Environment map by Paul Debevec
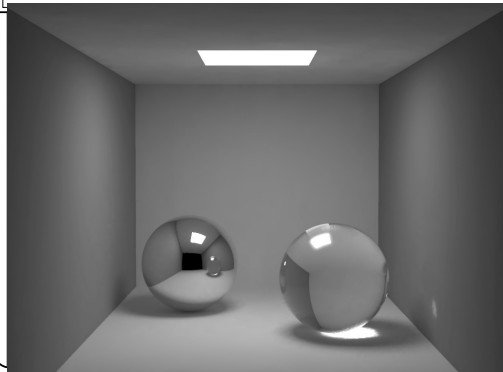

Traditional Ray Tracing

Ray Tracing+soft shadows

Ray Tracing+caustics

Global Illumination

shadows

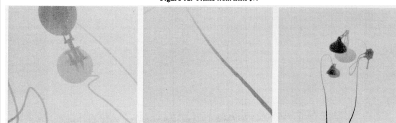Figure 12. Frame from *Luxo Jr.*

Figure 13. Shadow maps from *Luxo Jr.*

Image-based Rendering

- Use images as inputs and representation
- E.g. Image-based modeling and photo editing
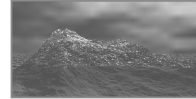 Boh, Chen, Dorsey and Durand 2001
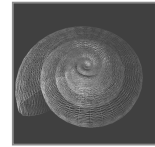
Input image   New viewpoint   Relighting

Modeling

- Representations of geometry
  ○ Curves: splines
  ○ Surfaces: meshes, splines, subdivision
  ○ Solids: voxels, CSG, BSP

- Procedural modeling
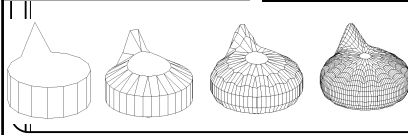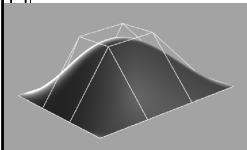 ○ Sweeps
  ○ Fractals
  ○ Grammars

Shell
(Douglas Turnbull, CS 426, Fall99)

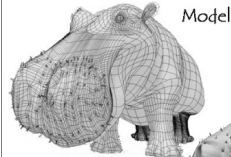Scenery Designer
(Dirk Balfanz, Igor Guskov, Sanjeev Kumar, & Rudro Samanta, CS426, Fall95)

Modeling

- Curved surfaces
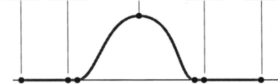- Subdivision surfaces

Textures and shading

Model

Model + Shading

Model + Shading + Textures

At what point do things start looking real?

▪ For more info on the computer artwork of Jeremy Birn see http://www.3drender.com/jbirn/productions.html

Animation: Keyframing

ACM © 1987 "Principles of traditional animation applied to 3D computer animation"
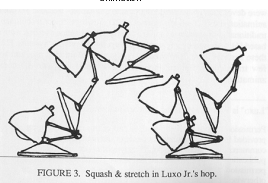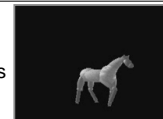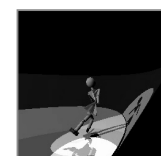
FIGURE 3. Squash & stretch in Luxo Jr.'s hop.

Animation

- Keyframing
  ○ Kinematics
  ○ Articulated figures

- Motion capture
  ○ Capture
  ○ Warping

Mr. Ed
(Casey McTaggert, CS426, Fall99)

- Dynamics
  ○ Physically-based simulations
  ○ Particle systems

- Behaviors
  ○ Planning, learning, etc.

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

Questions
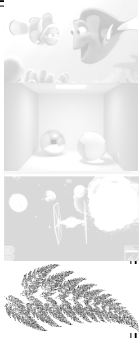
What is Computer Graphics?

- Computer Graphics deals with the tools that one needs in order to:
  - create mathematical models of 2D and 3D objects (**geometric modeling**)
  - produce images given geometrical models (**rendering**)
  - define/represent time-dependent behavior of objects (**animation**). ("*Geometric Modeling*" + "*Rendering*" in 4D.)

Geometric Modeling

- From a concept (or a real object) to a geometric model on a computer.
- Example: a sphere can be described as (x,y,z,r).
- More complex objects can be constructed from simpler ones.
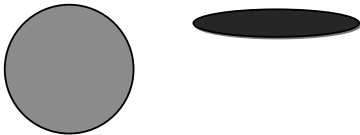
Mesh Representation
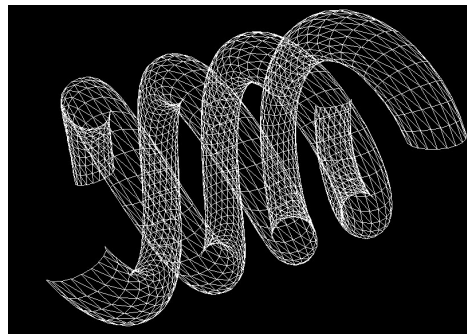
Mesh Representation

Mesh Representation

Mesh Representation

Vertex list	Triangle list
x,y,z,c	i,j,k
x,y,z,c	...
...	...
x,y,z,c	...
	i,j,k

Ignoring attributes, <u>topology</u> is about twice as larger as the <u>geometry</u>
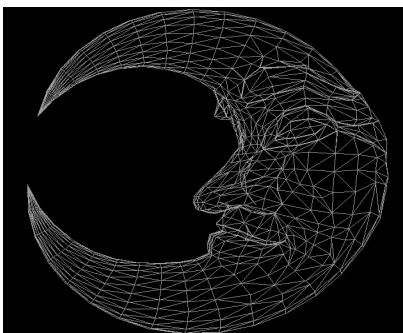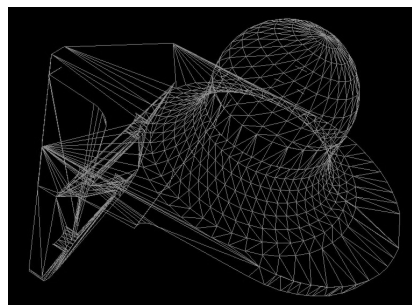

Overview

- 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

Programming Assignments

There will be four assignments:

- Image space – half toning (10%)
- 3D Rendering - Ray Casting + Shading (10%)
- Image Space Morphing (10%)
- OpenGL (TBD) (10%)

Survival Guide

- Assignments: 40%
  - Must be completed individually or in pairs
  - No late policy.
- 2-3 Optional Exercises: 30%
  - 1 hour in class
- Final exam: 60% (or down to 30%)

Collaboration Policy

- Overview:
  - Working in pairs?
  - 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

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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."