Syllabus

I. Image processing

II. Modeling

III. Rendering

IV. Animation

Image Processing
(Rusty Coleman, CS426, Fall99)

Modeling
(Dennis Zorin, CalTech)

Rendering
(Michael Bostock, CS426, Fall99)

Animation
(Angel, Plate 1)
What is 3D Rendering?

• Topics in computer graphics
  ◦ Imaging = representing 2D images
  ◦ Modeling = representing 3D objects
  ◦ Rendering = constructing 2D images from 3D models
  ◦ Animation = simulating changes over time
What is 3D Rendering?

- Construct image from 3D model

Diagram:
- Camera
- Light
- View Plane
- 3D Model
- Rendering
- 2D Image
3D Rendering Scenario I

- Interactive
  - Images generated in fraction of a second (e.g., 1/30) as user controls rendering parameters (e.g., camera)
  - Achieve highest quality possible in given time
  - Useful for visualization, games, etc.
3D Rendering Scenario II

• Offline
  ◦ One image generated with as much quality as possible for a particular set of rendering parameters
    • Take as much time as is needed (minutes)
    • Photorealism: movies, cut scenes, etc.
3D Rendering Issues

• What issues must be addressed by a 3D rendering system?
3D Rendering Example
3D Rendering Issues

• What issues must be addressed by a 3D rendering system?
3D Rendering Issues

• What issues must be addressed by a 3D rendering system?
  ◦ Camera
  ◦ Visible surface determination
  ◦ Lights
  ◦ Reflectance
  ◦ Shadows
  ◦ Indirect illumination
  ◦ Sampling
  ◦ etc.
3D Rendering Issues

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- etc.
Camera Models

- The most common model is pin-hole camera
  - Light rays arrive along paths toward focal point
  - No lens effects (e.g., everything in focus)
Camera Parameters

- What are the parameters of a pin-hole camera?
Pinhole Camera Parameters

- **Position**
  - Eye position \((p_x, p_y, p_z)\)

- **Orientation**
  - View direction \((d_x, d_y, d_z)\) or “look at” point
  - Up direction \((u_x, u_y, u_z)\)

- **Coverage**
  - Field of view \((\text{fov}_x, \text{fov}_y)\)

- **Resolution**
  - \(x\) and \(y\)
View Plane

Other camera models consider ...
Depth of field
Motion blur
Lens distortion
3D Rendering Issues

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  - etc.
Visible Surface Determination

- The color of each pixel on the view plane depends on the radiance ("amount of light") emanating from visible surfaces.

How find visible surfaces?
Figure 29. Characterization of ten opaque-object algorithms & Comparison of the algorithms.
Ray Casting

• For each sample …
  ◦ Construct ray from eye position through view plane
  ◦ Find first surface intersected by ray through pixel
  ◦ Compute color of sample based on surface radiance
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Ray Casting Example

Rays from camera in simple scene
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Lighting Simulation

- Lighting parameters
  - Light source emission
  - Surface reflectance
  - Atmospheric attenuation
  - Camera response
Lighting Simulation

Diagram showing two light sources, L1 and L2, illuminating a surface with normal vectors N and V. The viewer is positioned to observe the effect of the lighting simulation.
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  - etc.
Shadows

• Occlusions from light sources
Shadows

- Occlusions from light sources
  - Soft shadows with area light source
Shadows
3D Rendering Issues

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Indirect Illumination
Indirect Illumination

$L(D|S|T)*E$

+ indirect diffuse illumination

Henrik Wann Jensen
3D Rendering Issues

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Sampling

- Scene can be sampled with any ray
  - Rendering is a problem in sampling and reconstruction
Summary

• Topics for after spring break
  ◦ Camera
  ◦ Visible surface determination
  ◦ Shadows
  ◦ Reflectance
  ◦ Indirect illumination
  ◦ Sampling
  ◦ etc.

Tricycle
(James Percy, CS 426, Fall 99)