

3D Rendering

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Princeton University
COS 426, Spring 2007

Syllabus

I. Image processing

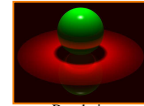
II. Modeling

III. Rendering

IV. Animation



Image Processing
(Rusty Coleman, CS426, Fall99)



Rendering
(Michael Bostock, CS426, Fall99)



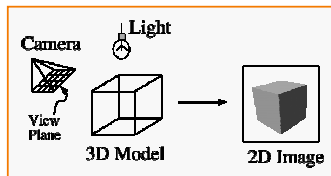
Modeling
(Dennis Zorin, CalTech)



Animation
(Angel, Plate 1)

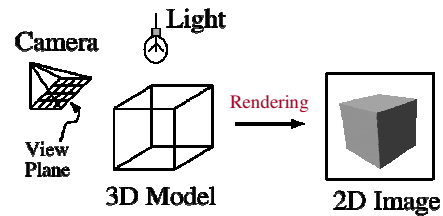
What is 3D Rendering?

- 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



3D Rendering Scenario I

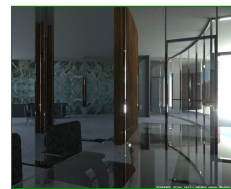
- Interactive
 - Images generated in fraction of a second ($<1/10$) as user controls rendering parameters (e.g., camera)
 - Achieve highest quality possible in given time
 - Useful for visualization, games, etc.



meshview

3D Rendering Scenario II

- Batch
 - One image generated with as much quality as possible for a particular set of rendering parameters
 - Take as much time as is needed (minutes)
 - Useful for photorealism, movies, etc.



Jensen

3D Rendering Example



Pixar

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
 - Shadows
 - Reflectance
 - Indirect illumination
 - Sampling
 - etc.

3D Rendering Issues



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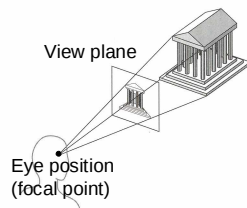
Camera Models



- The most common model is pin-hole camera
 - All captured light rays arrive along paths toward focal point without lens distortion (everything is in focus)
 - Sensor response proportional to radiance

Other models consider ...

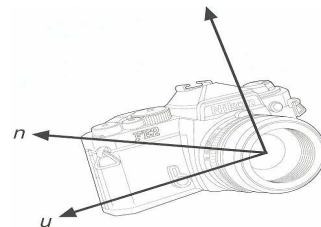
- Depth of field
- Motion blur
- Lens distortion



Camera Parameters

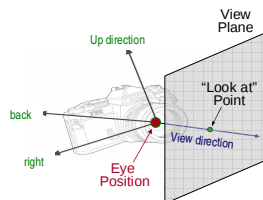


- What are the parameters of a camera?

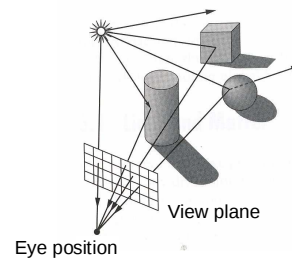


Pinhole Camera Parameters

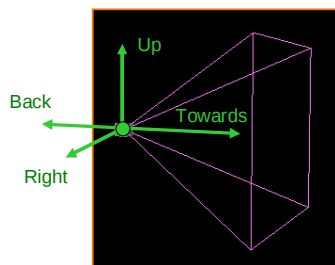
- Position
 - Eye position (p_x, p_y, p_z)
- Orientation
 - View direction (d_x, d_y, d_z)
 - Up direction (u_x, u_y, u_z)
- Aperture
 - Field of view ($xfov, yfov$)
- Film plane
 - "Look at" point
 - View plane normal



View Plane

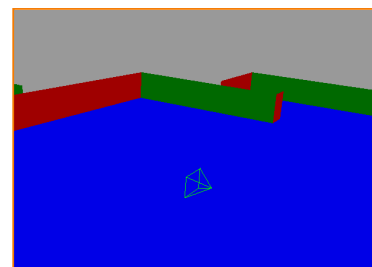


View Frustum



View Frustum

View Frustum Example



View frustum inside simple scene

3D Rendering Issues

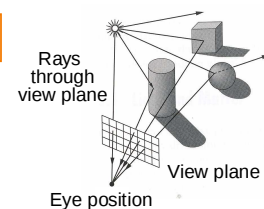
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Visible Surface Determination

- The color of each pixel on the view plane depends on the radiance emanating from visible surfaces

How find visible surfaces?

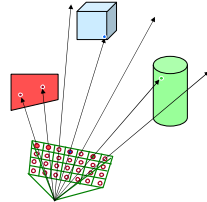
Simplest method is ray casting



Ray Casting



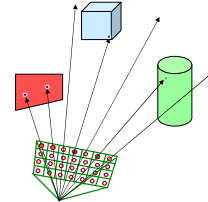
- For each sample ...
 - Construct ray from eye position through view plane
 - Find first surface intersected by ray through pixel
 - Compute color of sample based on surface radiance



Ray Casting



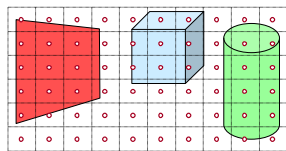
- For each sample ...
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Ray Casting



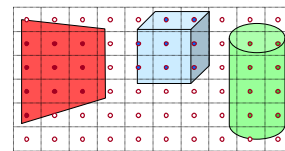
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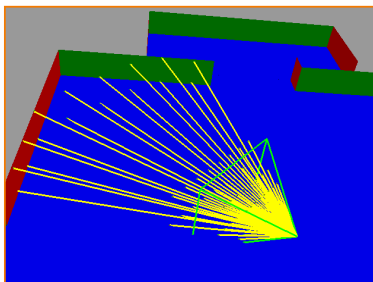
Visible Surface Determination



- 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~~



Ray Casting Example



Rays from camera in simple scene

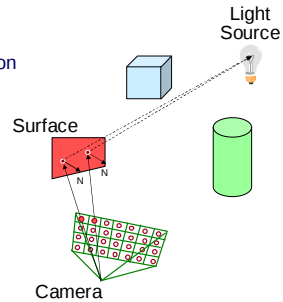
3D Rendering Issues



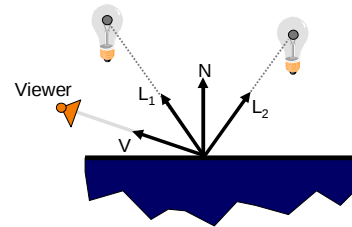
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 - ~~Lights~~
 - ~~Reflectance~~
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 - etc.

Lighting Simulation

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

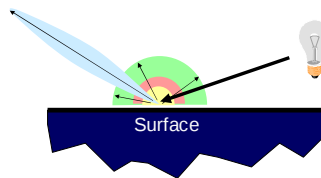


Lighting Simulation

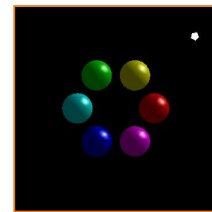


OpenGL Reflectance Model

- Simple analytic model:
 - diffuse reflection +
 - specular reflection +
 - emission +
 - "ambient"



Lighting Example

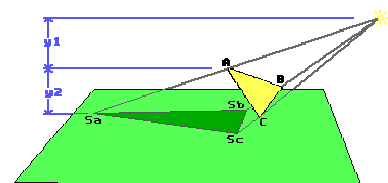


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Shadows

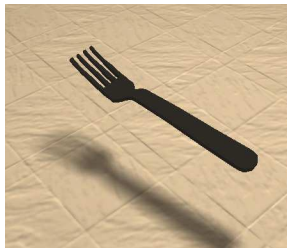
- Occlusions from light sources



Shadows



- Occlusions from light sources
 - Soft shadows with area light source



Moller

Shadows



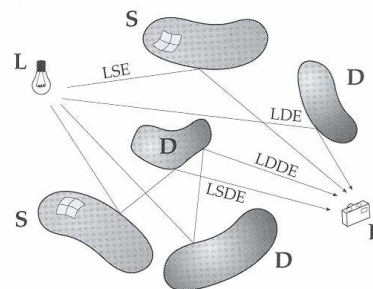
Herf

3D Rendering Issues



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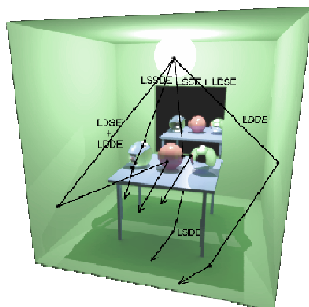
Path Types



Path Types

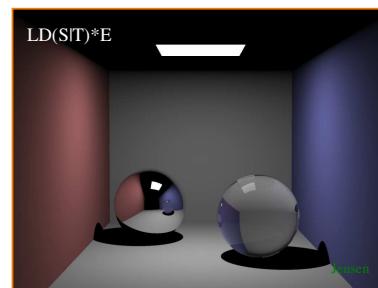


- OpenGL
 - LDE
- Ray tracing
 - $LD(S|T)*E$
- Path tracing
 - $L(D|S|T)*E$
- Radiosity
 - $LD*E$



John Hart

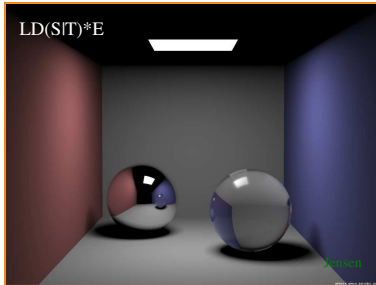
Path Types



direct diffuse + indirect specular and transmission

Henrik Wann Jensen

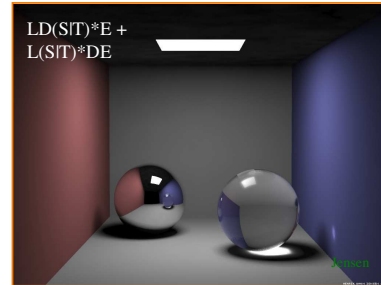
Path Types



+ soft shadows

Henrik Wann Jensen

Path Types



+ caustics

Henrik Wann Jensen

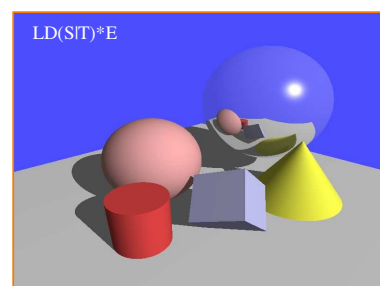
Path Types



+ indirect diffuse illumination

Henrik Wann Jensen

Path Types?



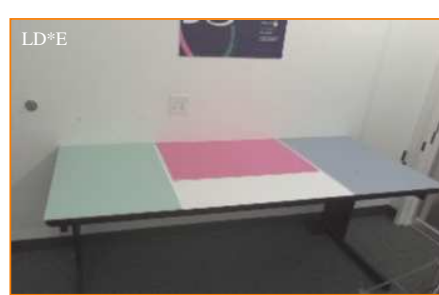
Henrik Wann Jensen

Path Types?



Henrik Wann Jensen

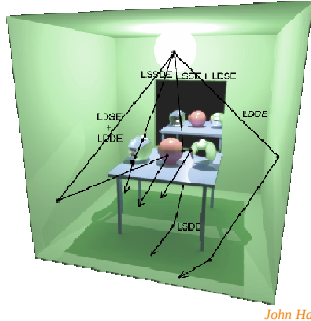
Path Types?



Paul Debevec

Path Types

- OpenGL
 - LDE
- Ray tracing
 - LDS*E
- Path tracing
 - L(D|S)*E
- Radiosity
 - LD*E



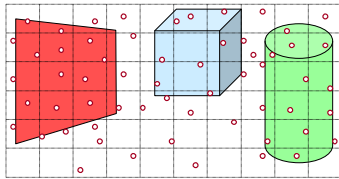
John Hart

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Sampling

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



Summary

- Topics for upcoming lectures
 - Camera
 - Visible surface determination
 - Shadows
 - Reflectance
 - Indirect illumination
 - Sampling
 - etc.



Tricycle
(James Percy, CS 426, Fall 1999)

For assignment #3, you will write a ray tracer!