



3D Rendering

COS 426

Syllabus



I. Image processing

II. Modeling

III. Rendering

IV. Animation

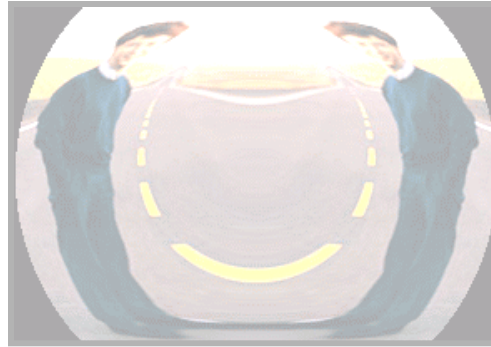
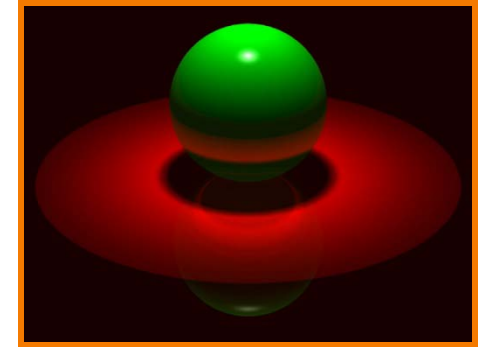


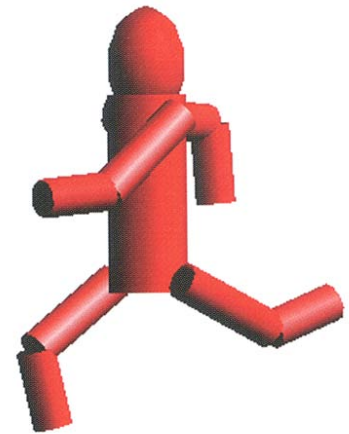
Image Processing
(Rusty Coleman, CS426, Fall99)



Rendering
(Michael Bostock, CS426, Fall99)



Modeling
(Dennis Zorin, CalTech)

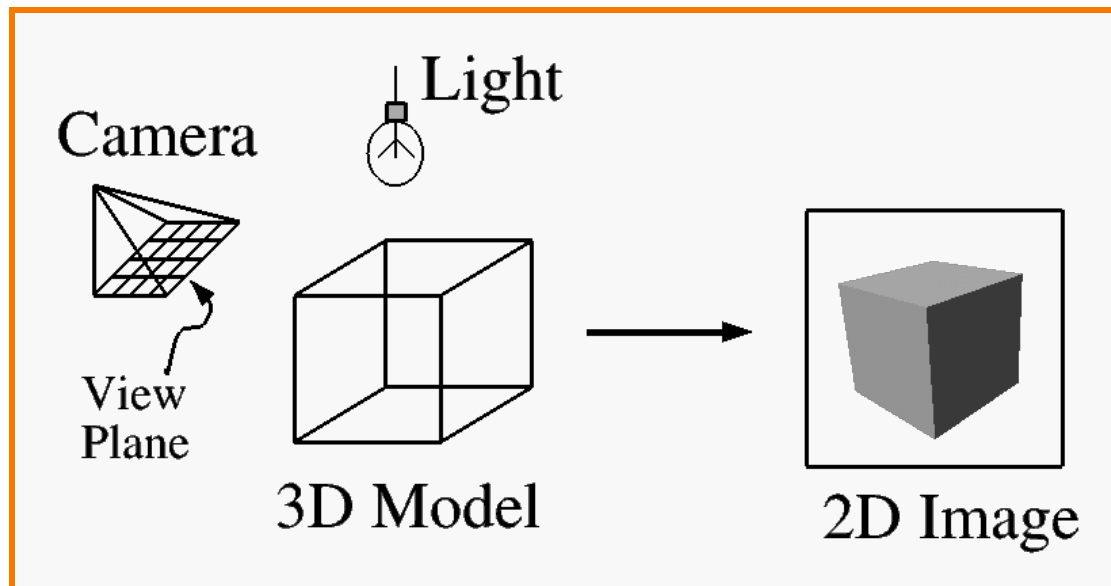


Animation
(Angel, Plate 1)



What is 3D Rendering?

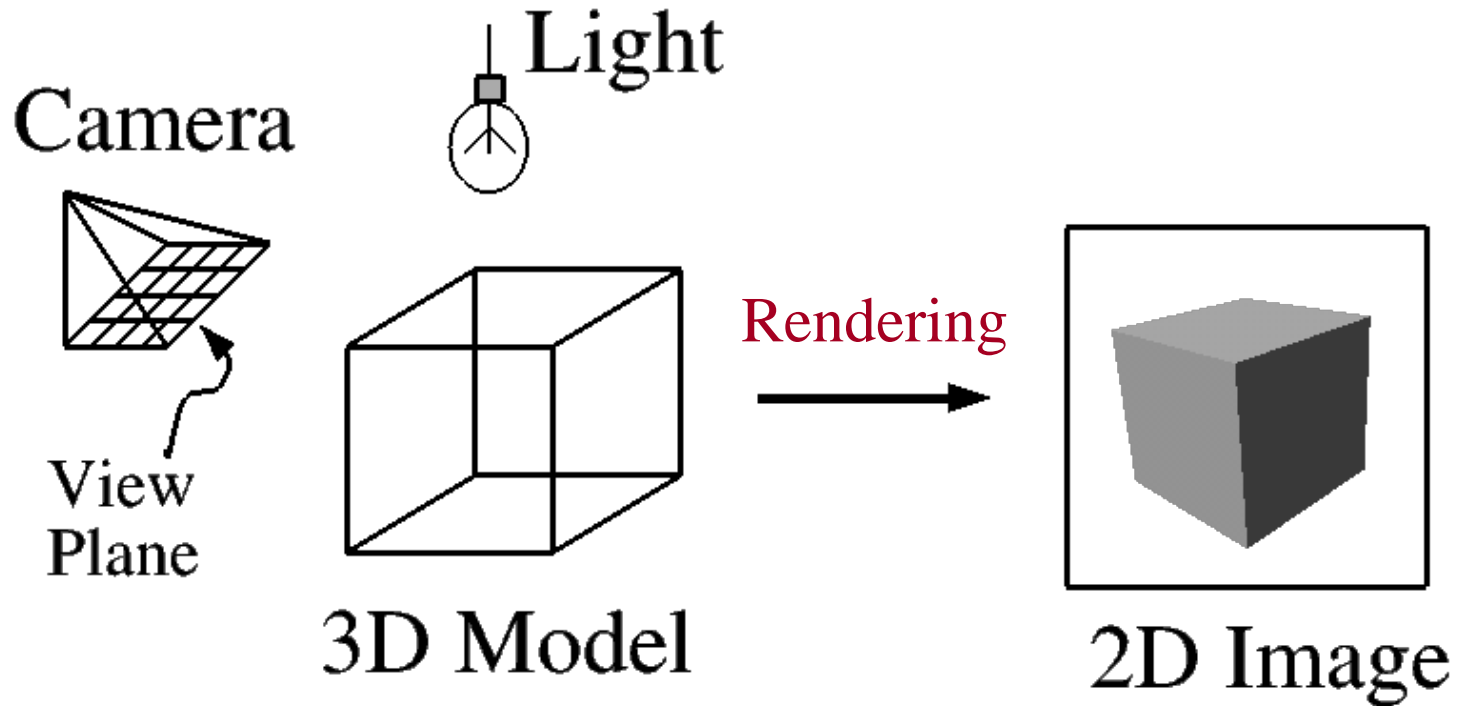
- Topics in computer graphics
 - Imaging = *representing 2D images*
 - Modeling = *representing 3D objects*
 - Rendering = *constructing 2D images from 3D models*
 - Animation = *simulating changes over time*





What is 3D Rendering?

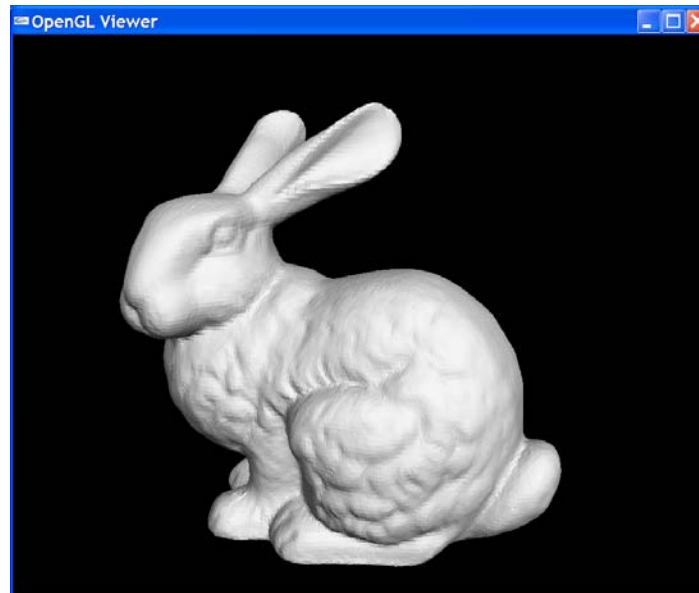
- Construct image from 3D model



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

- 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.



Avatar

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.



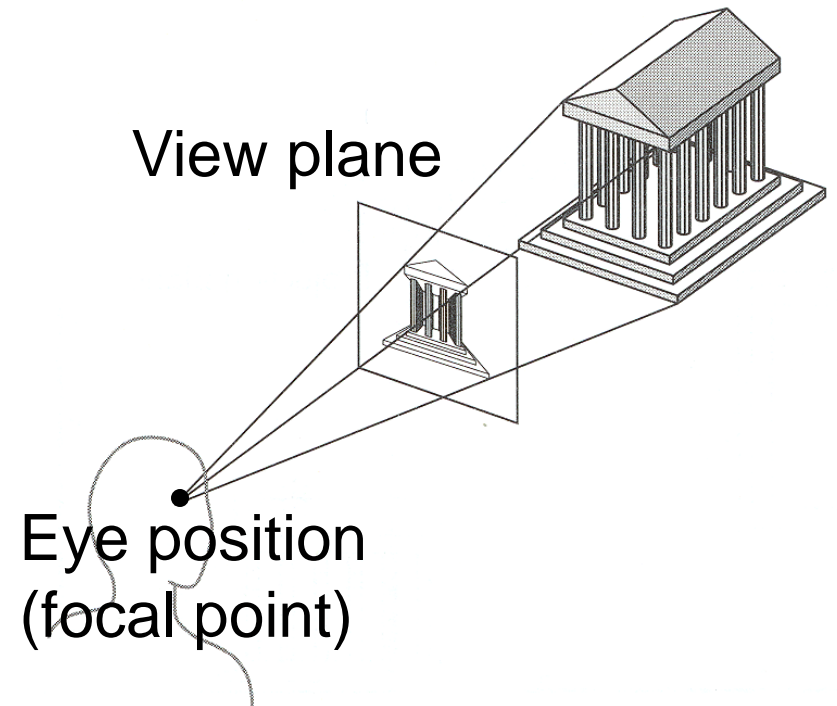
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Camera Models

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



Other models consider ...

Depth of field

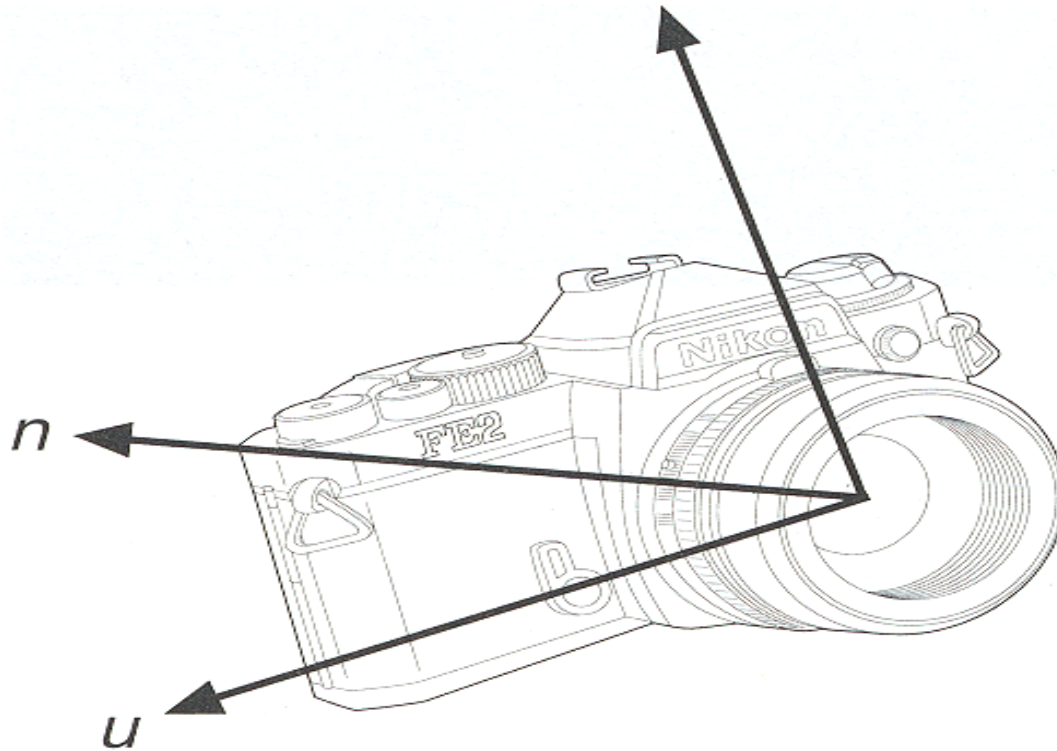
Motion blur

Lens distortion



Camera Parameters

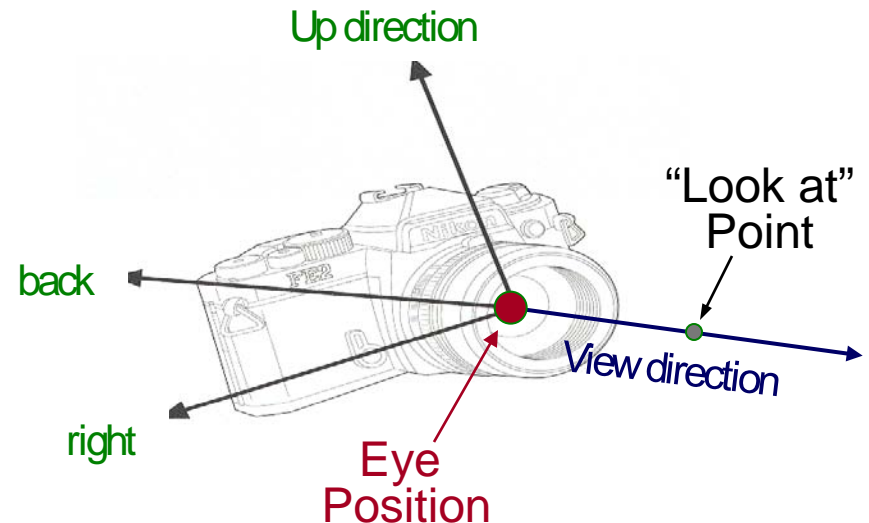
- What are the parameters of a camera?



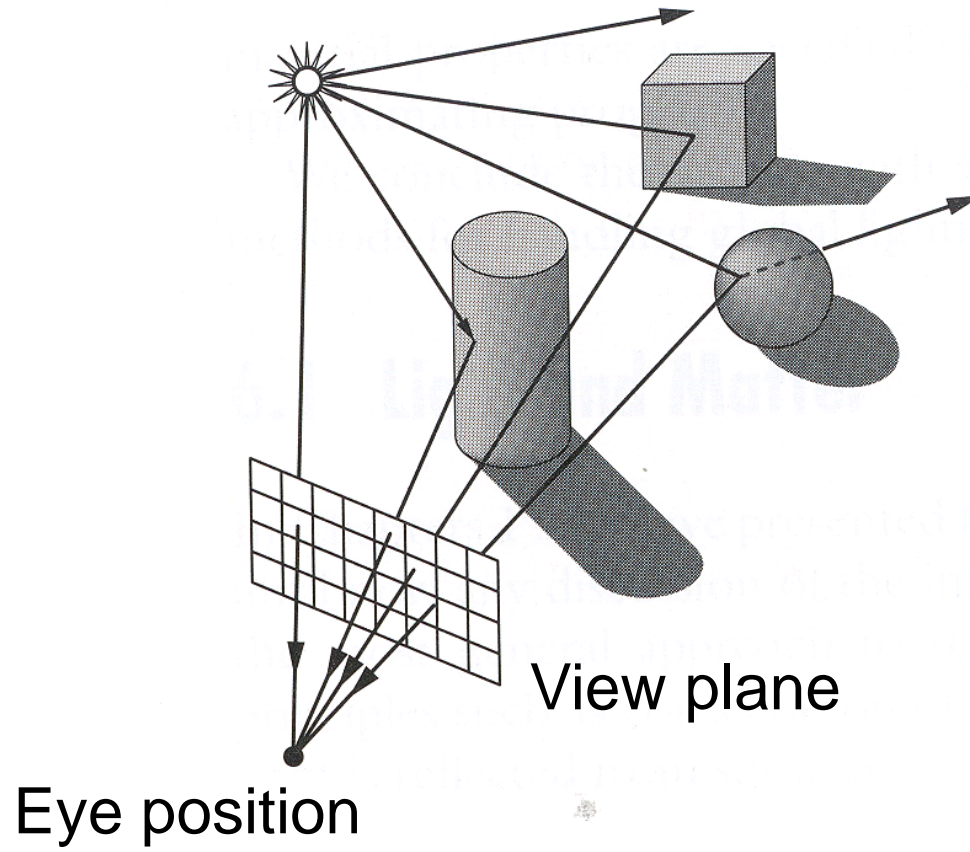


Pinhole Camera Parameters

- Position
 - Eye position (p_x, p_y, p_z)
- Orientation
 - View direction (d_x, d_y, d_z) or “look at” point
 - Up direction (u_x, u_y, u_z)
- Coverage
 - Field of view (fov_x, fov_y)
- Resolution
 - In x and y



View Plane





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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?

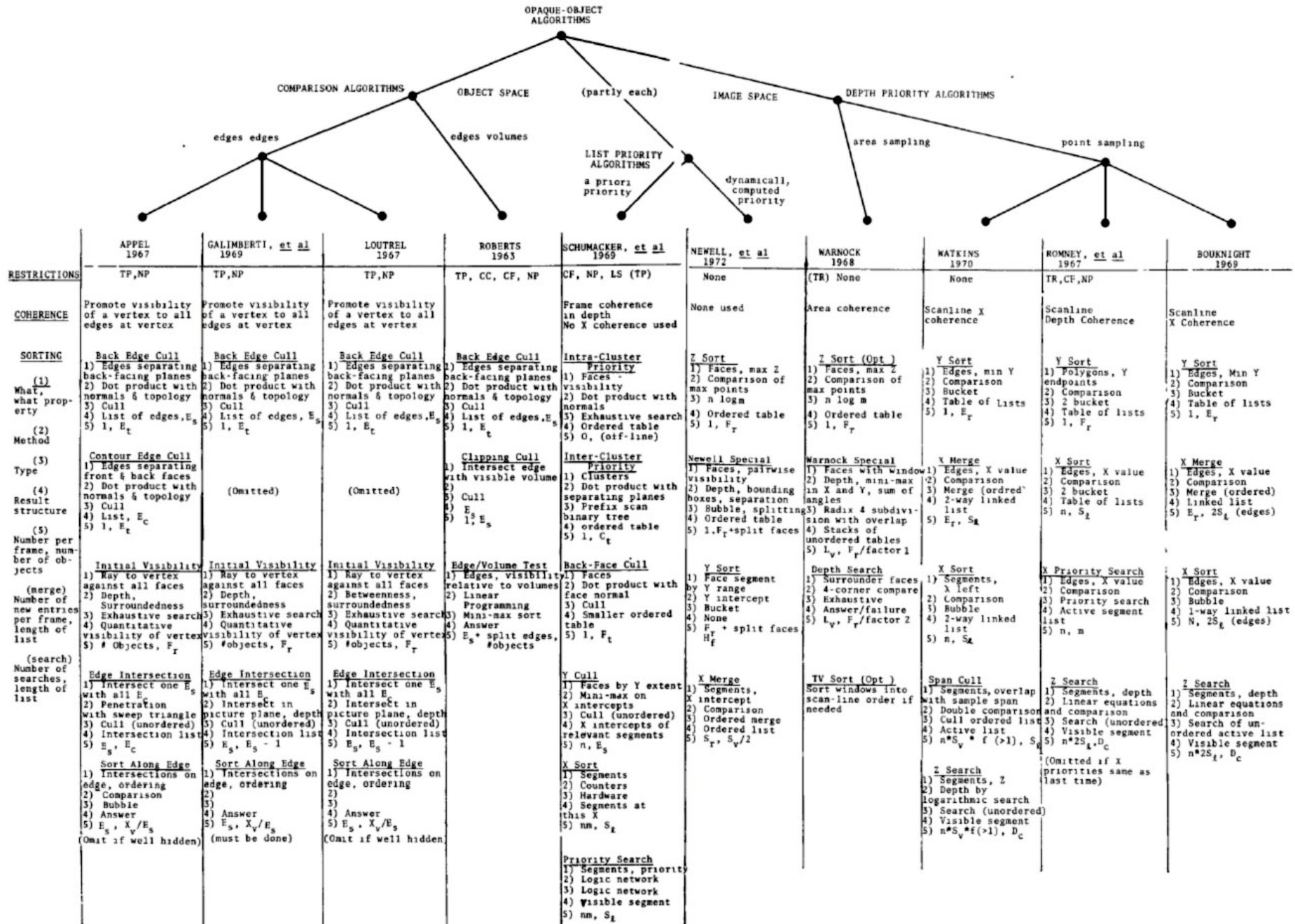


Figure 29. Characterization of ten opaque-object algorithms & Comparison of the algorithms.



In Practice... Brute Force

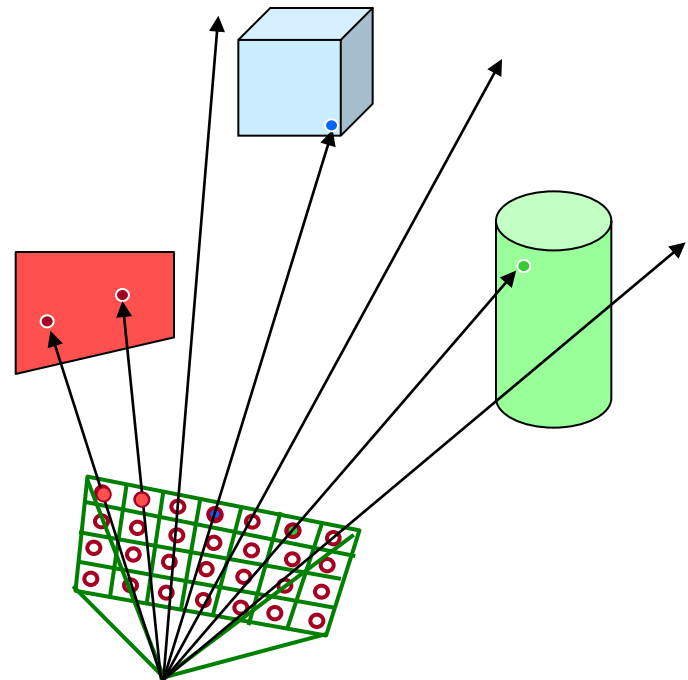
- **Ray tracing** (usually offline)
 - **for each** pixel: determine closest object hit by ray
 - compute color

- **Rasterization** (interactive)
 - **for each** object: enumerate pixels it hits
 - keep track of color, depth of current-best surface at each pixel



Ray Casting

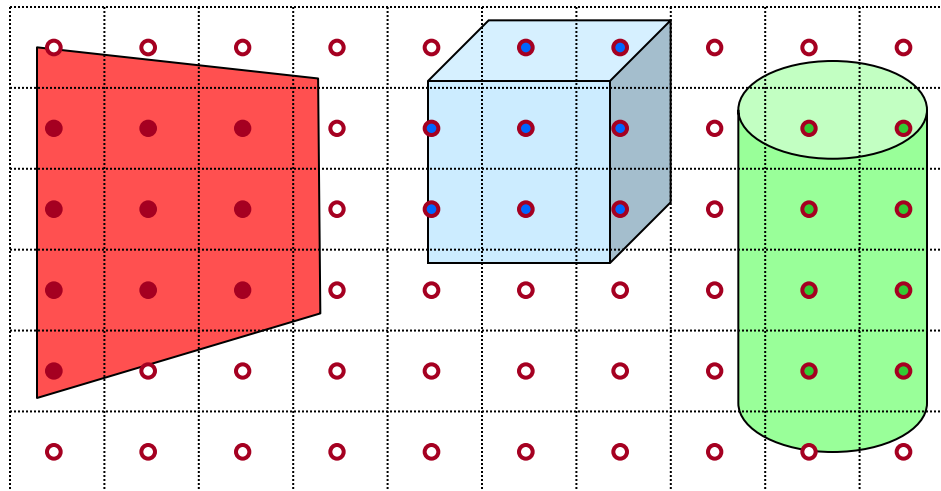
- For each sample ...
 - Construct ray from eye position through view plane
 - Find first surface intersected by ray through pixel
 - Compute color of sample based on surface radiance





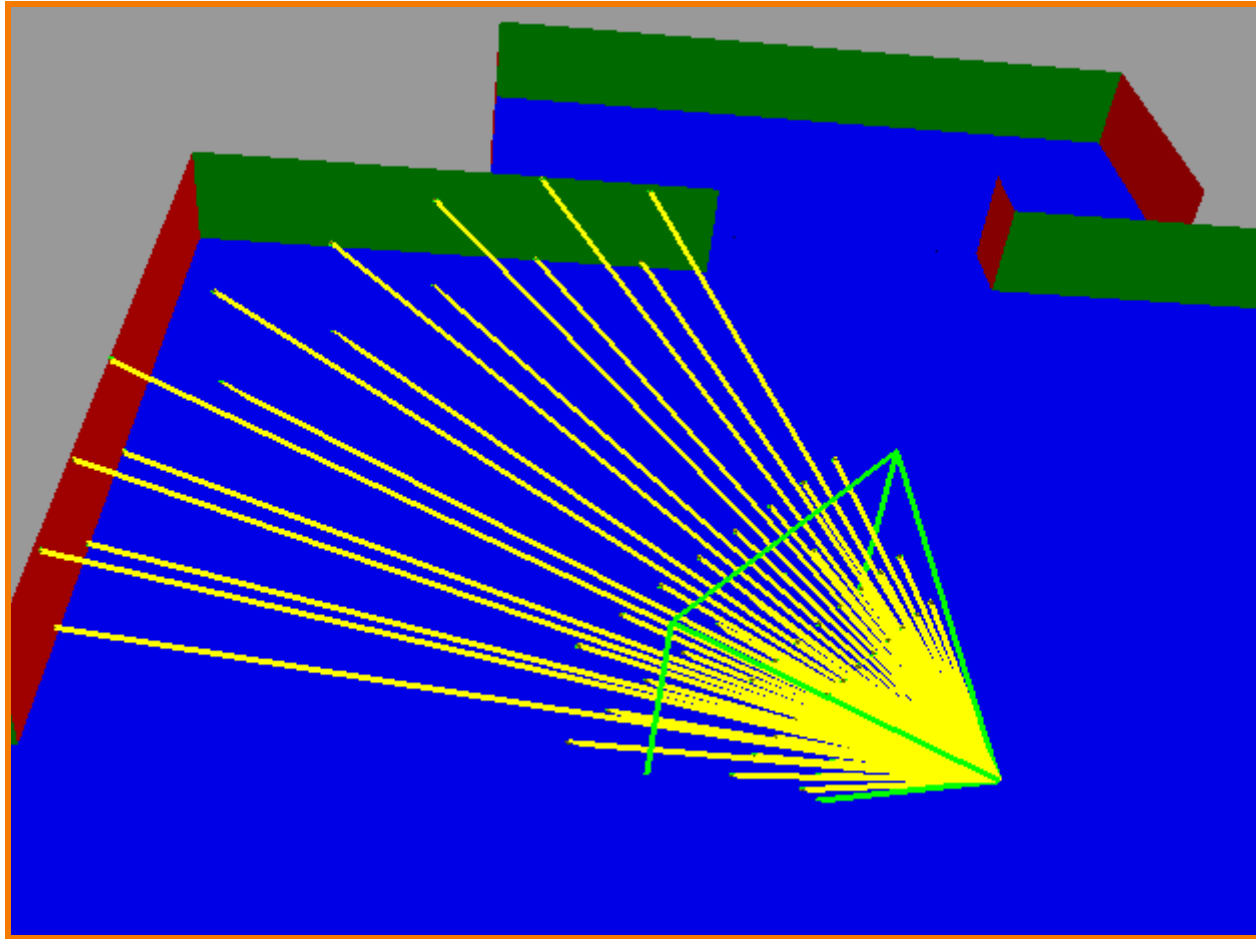
Ray Casting

- For each sample ...
 - Construct ray from eye position through view plane
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Ray Casting Example



Rays from camera in simple scene



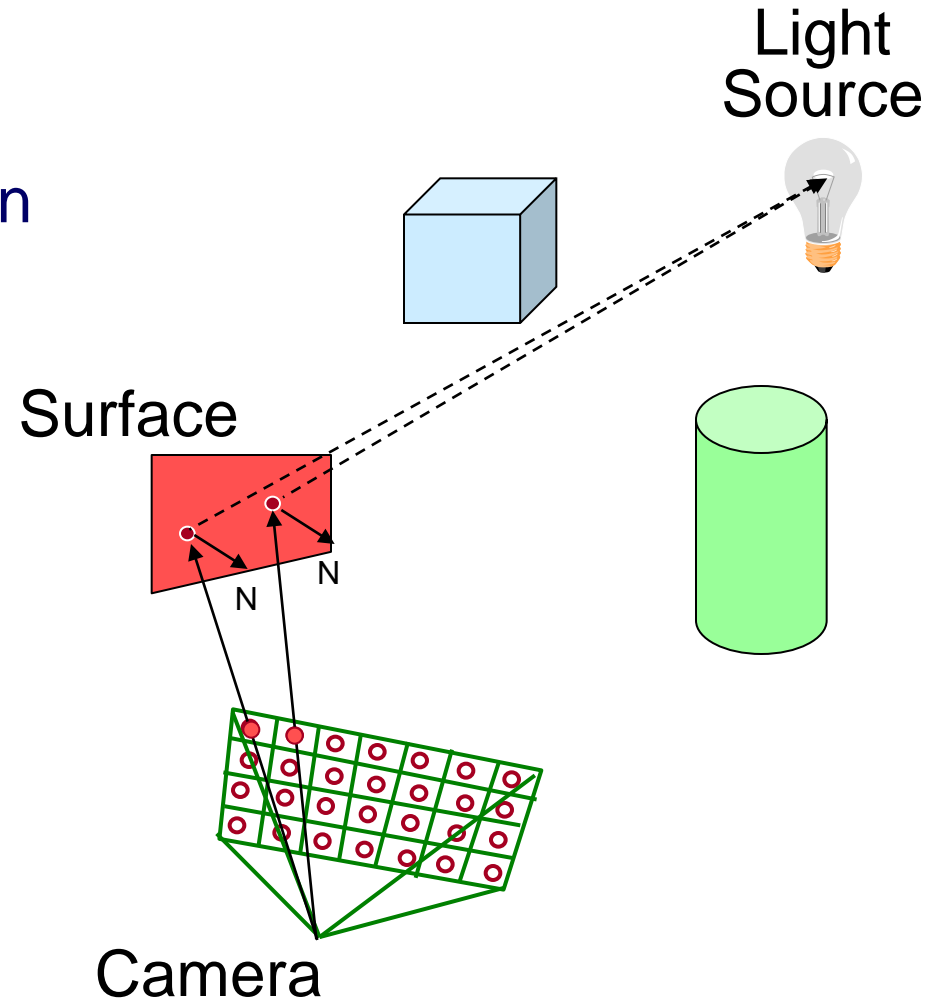
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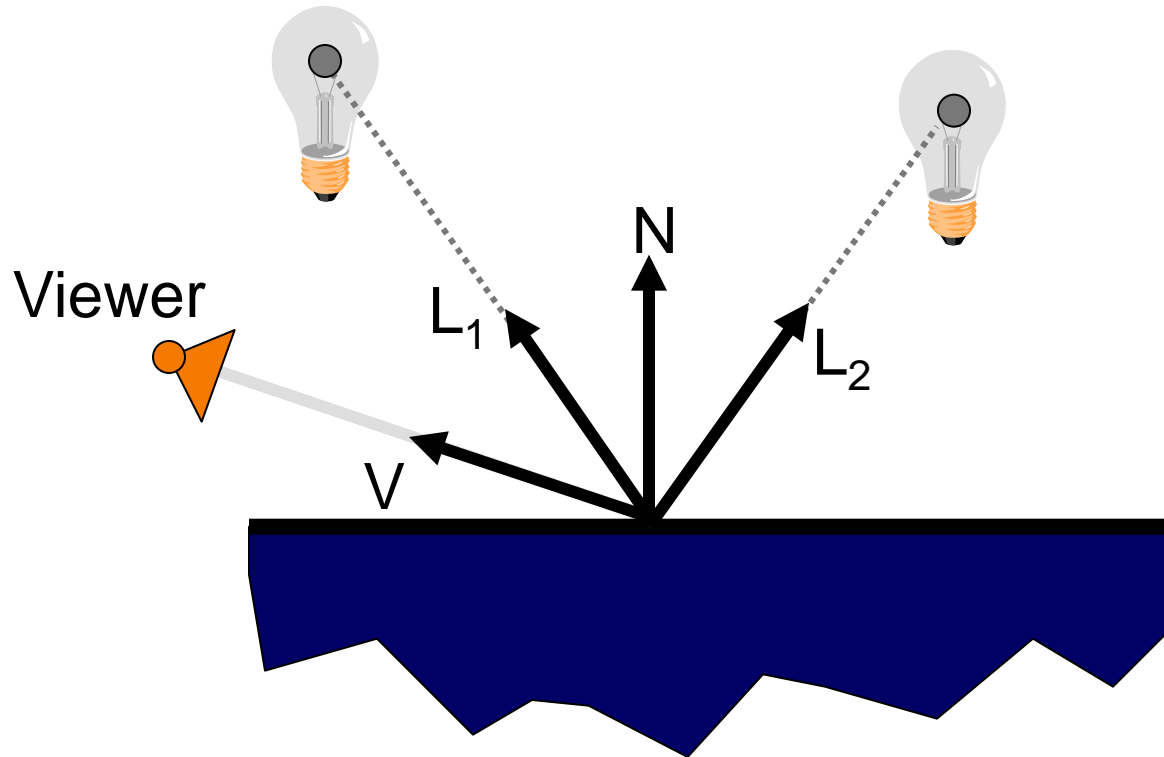


Lighting Simulation

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



Lighting Simulation





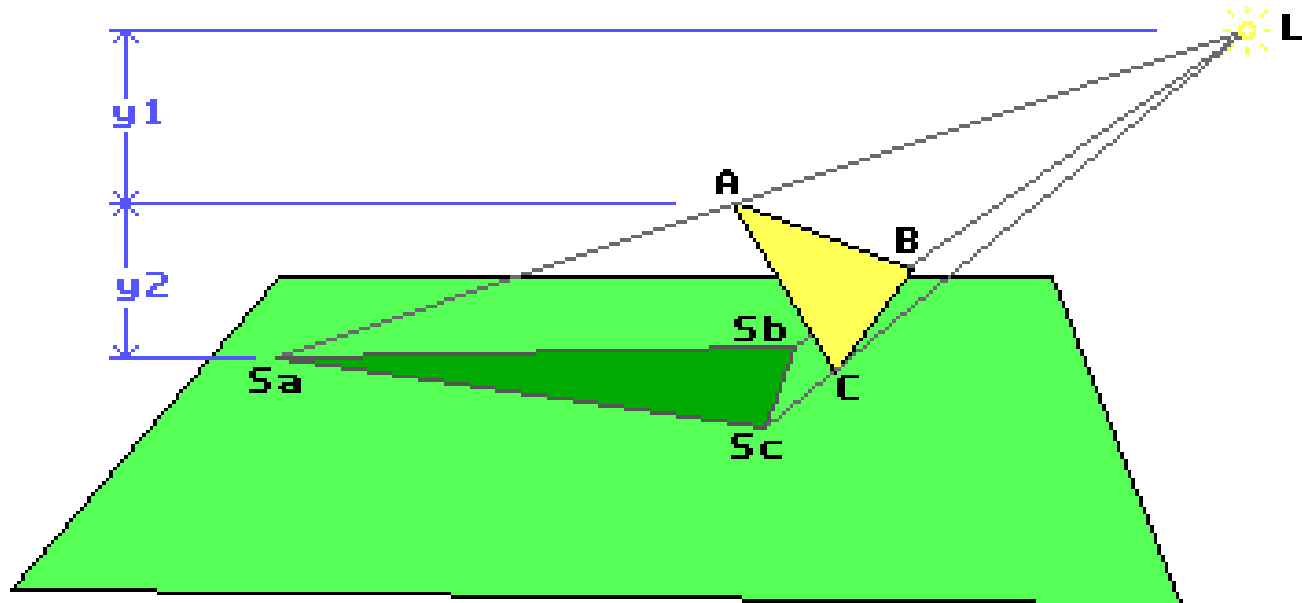
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 - **Shadows**
 - Indirect illumination
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 - etc.



Shadows

- Occlusions from light sources





Shadows

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



Shadows

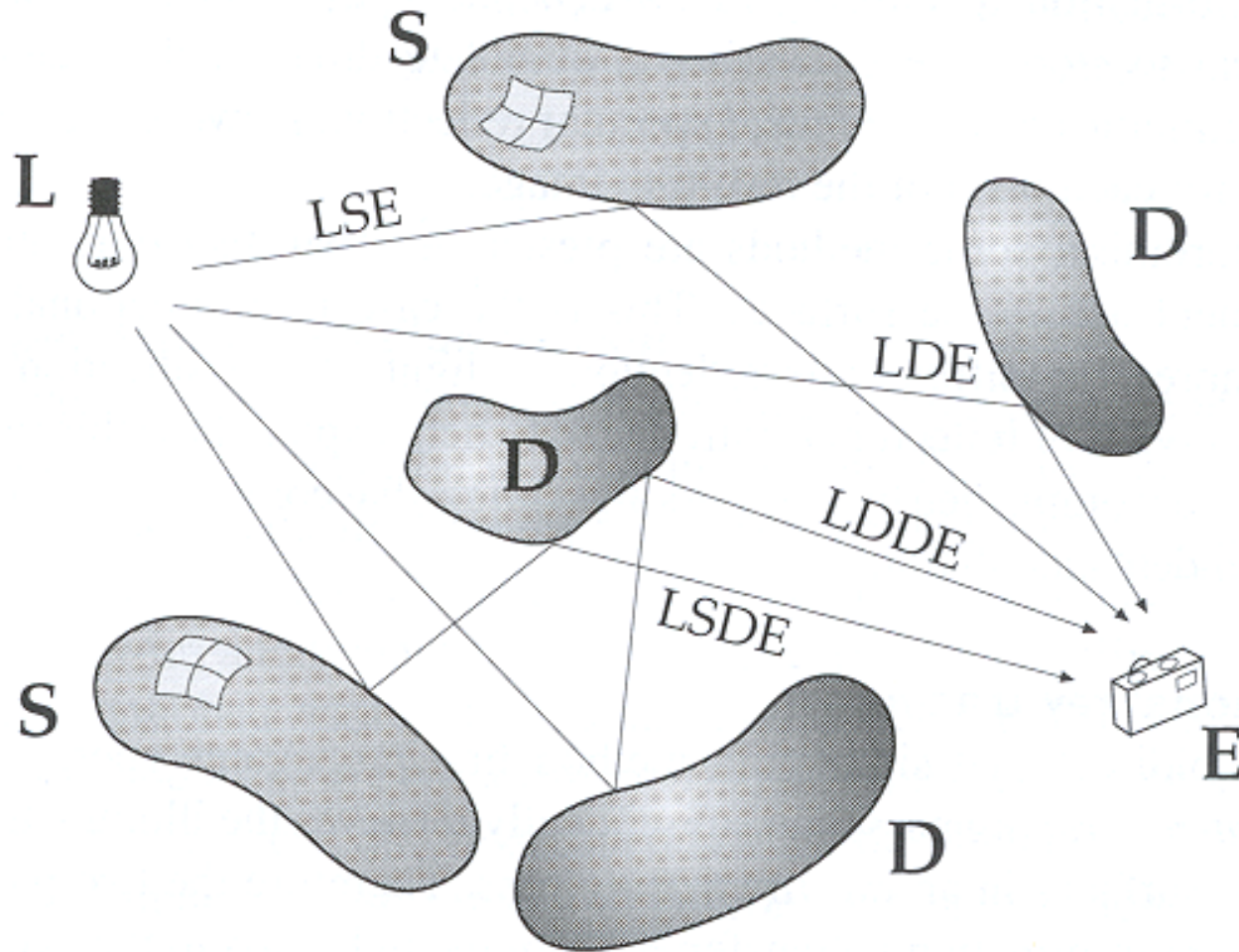




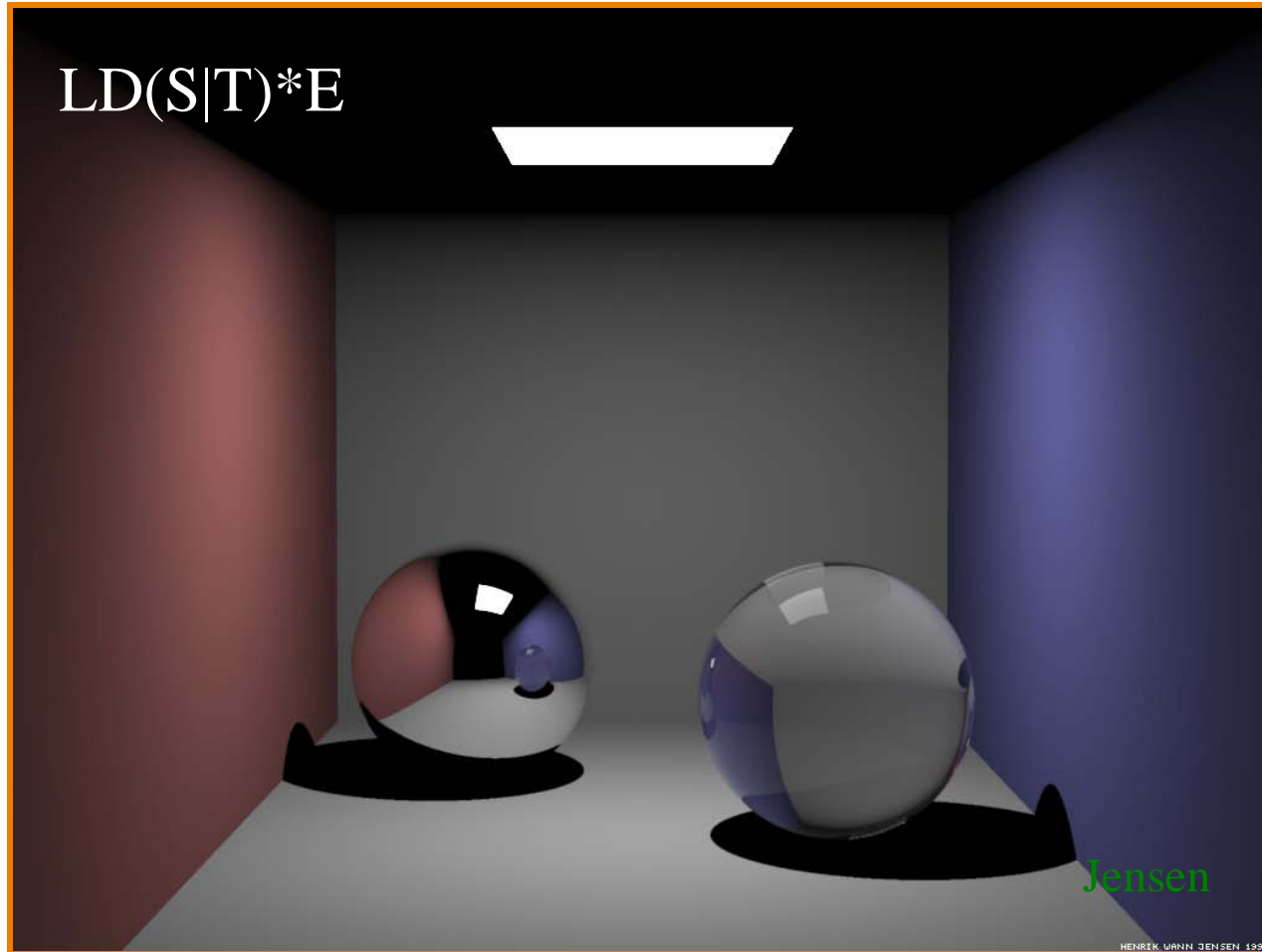
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Path Types



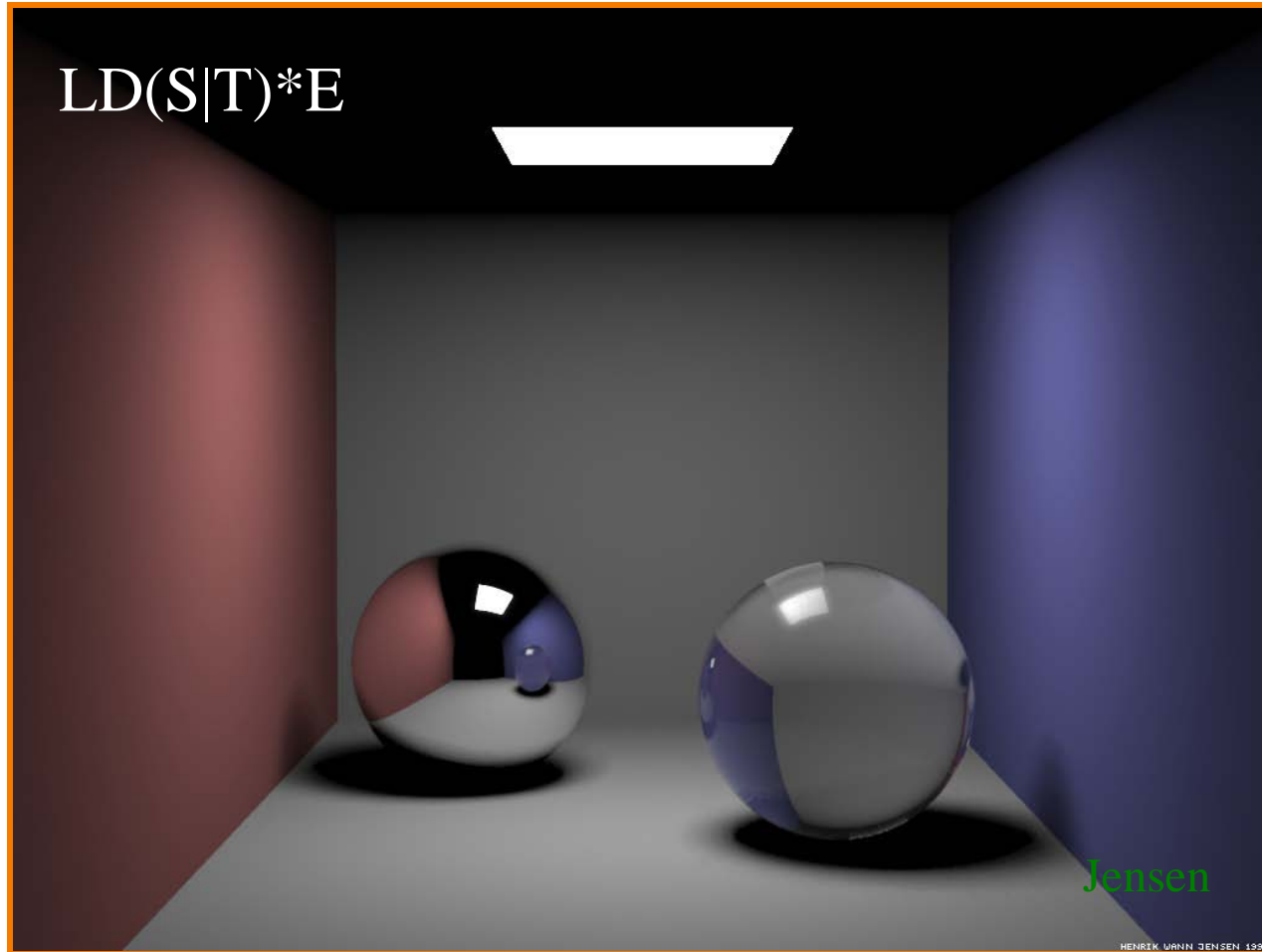
Path Types



direct diffuse + indirect specular and transmission

Henrik Wann Jensen

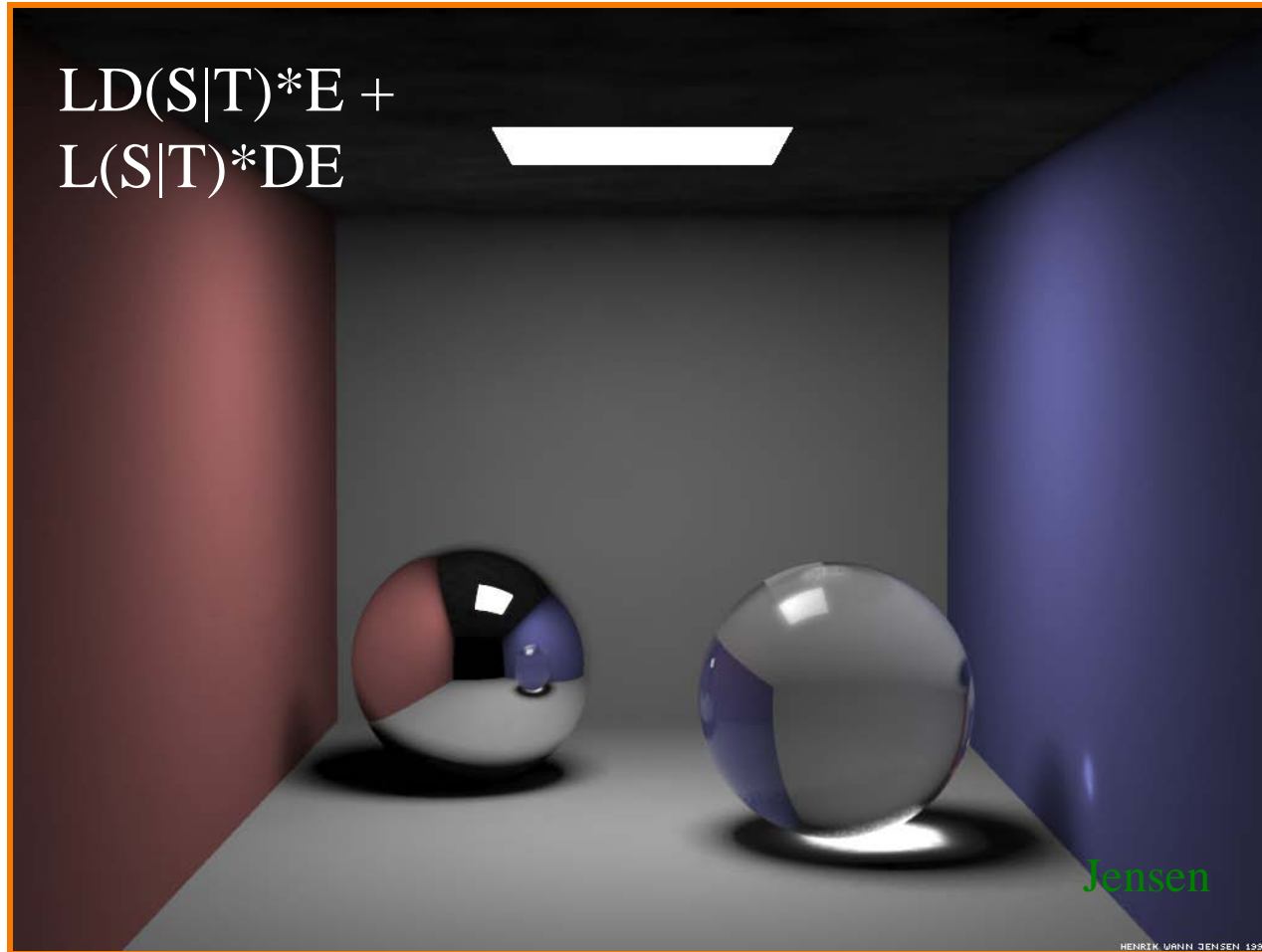
Path Types



+ soft shadows

Henrik Wann Jensen

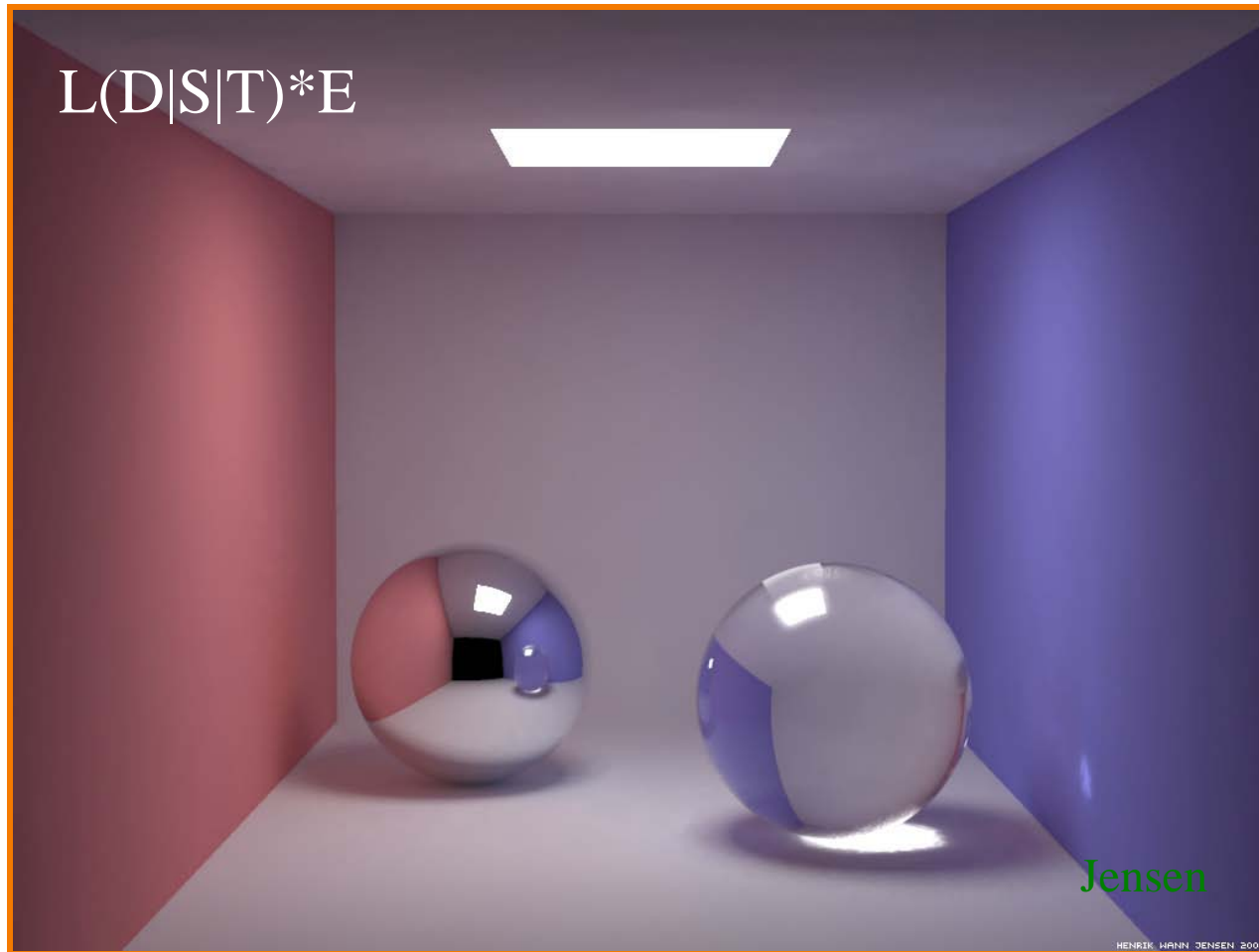
Path Types



+ caustics

Henrik Wann Jensen

Path Types



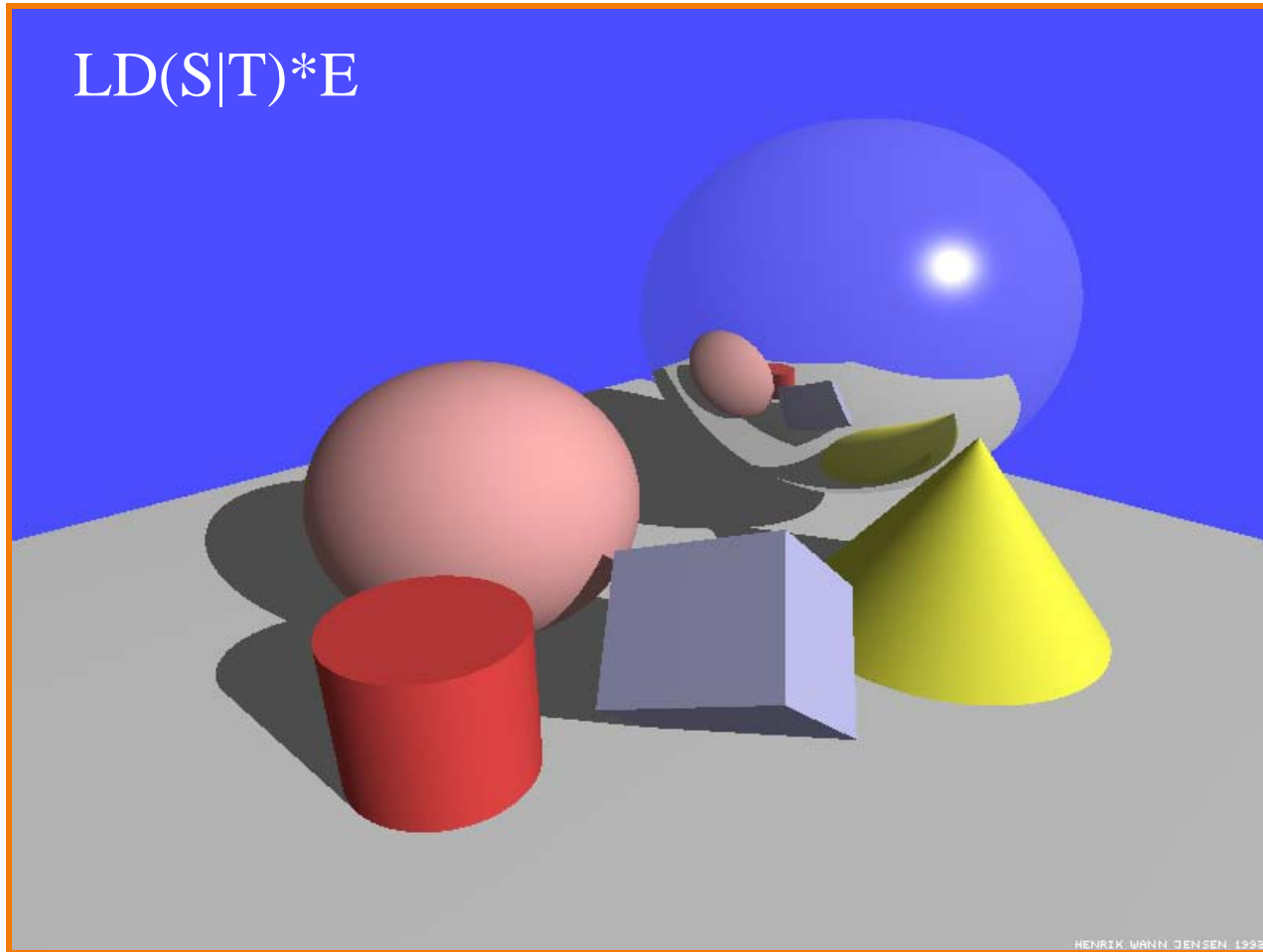
+ indirect diffuse illumination

Henrik Wann Jensen

Path Types?



LD(S|T)*E



HENRIK WANN JENSEN 1392

Path Types?



$LD(S|T)*E +$
 $L(S|T)*DE$



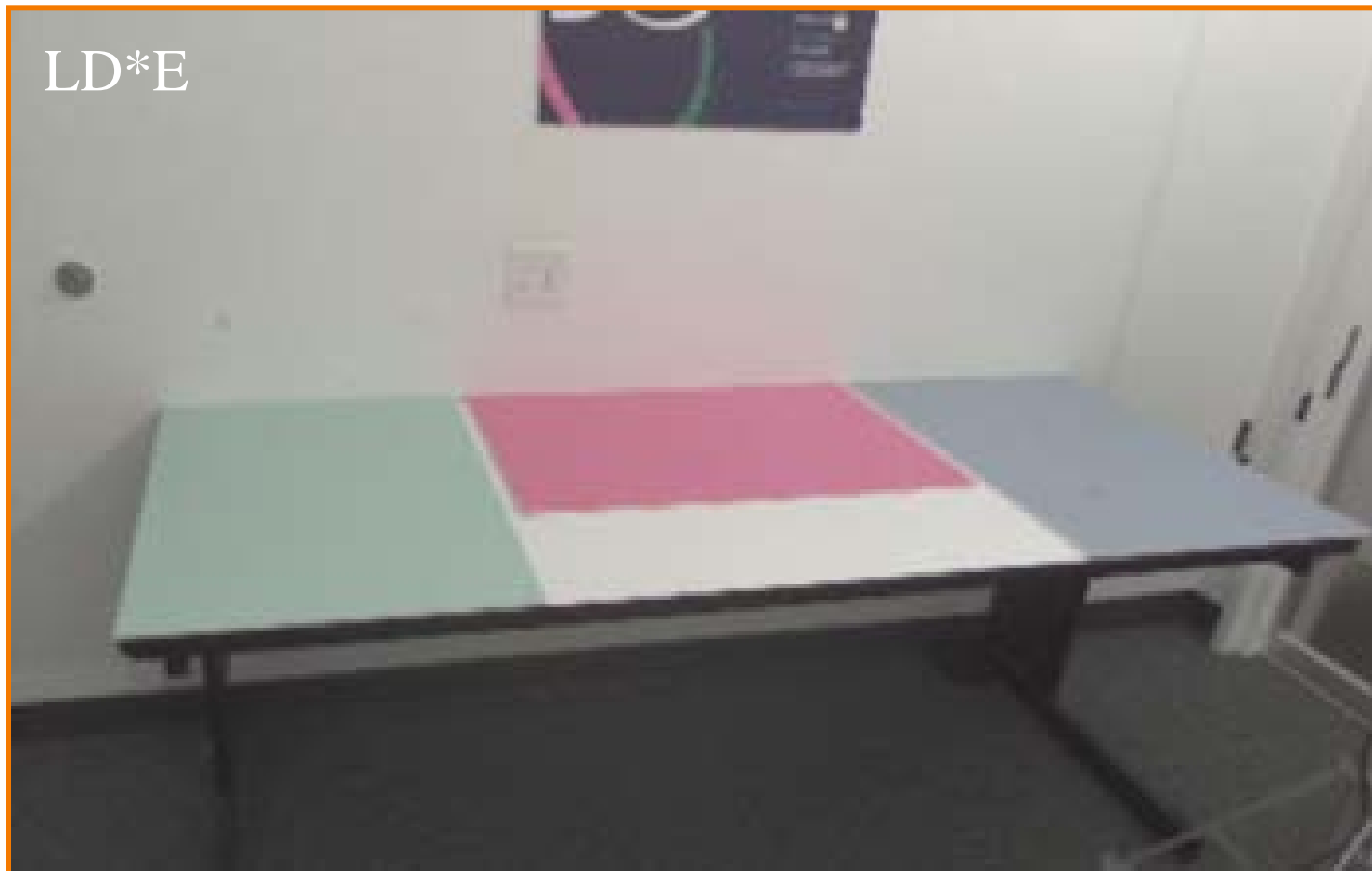
HENRIK WANN JENSEN 1996

Henrik Wann Jensen

Path Types?



LD*E

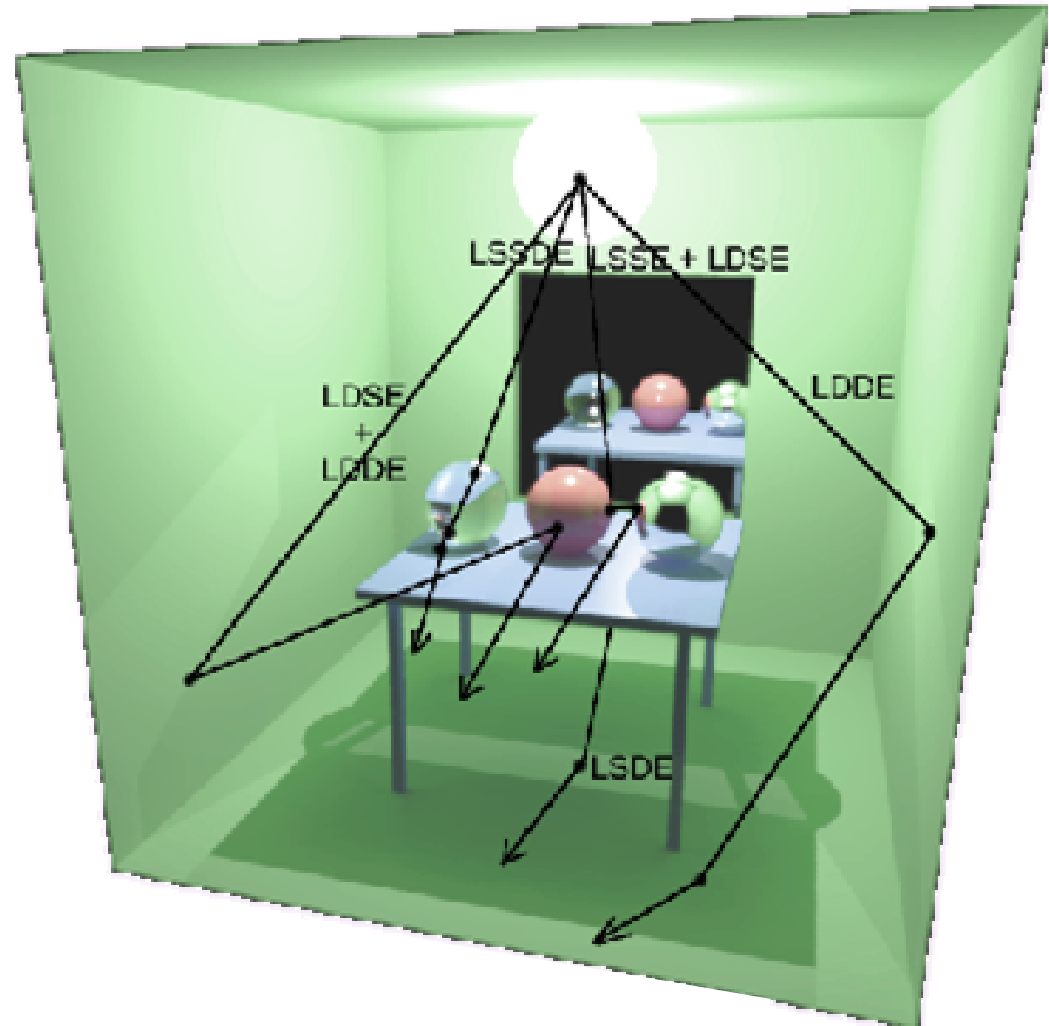


Paul Debevec



Path Types

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





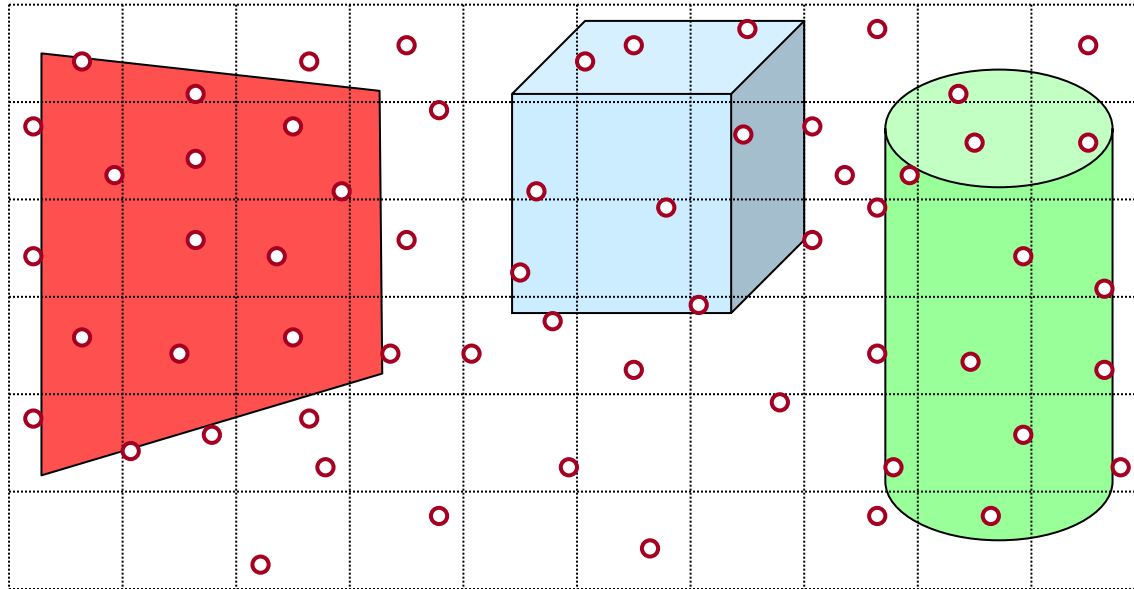
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Sampling

- 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, Fall99)

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