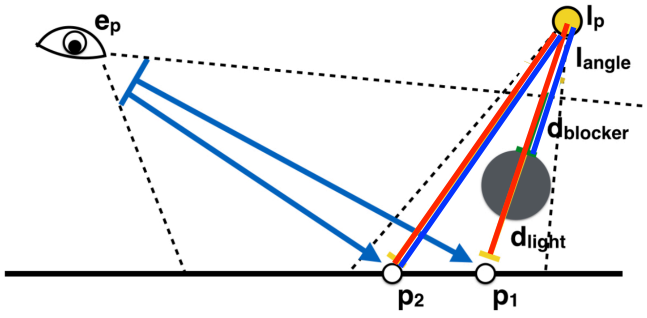
LIGHTING:
A FEW ADDITIONAL CONCEPTS

SHADOW MAPPING

Usually used with projective rendering

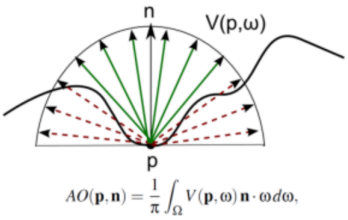


http://adrien.io/opengl-course/lesson-3-shadow-mapping/

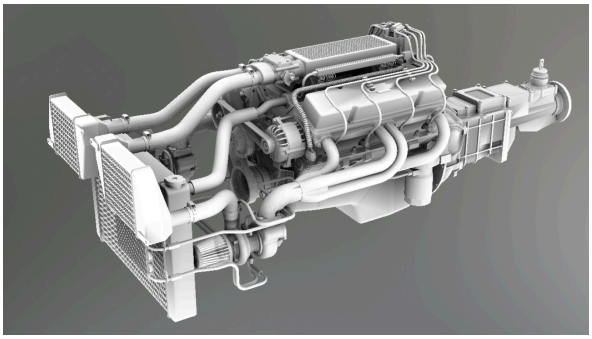
(1) render scene from light source; store the z-buffer
(2) render scene from camera view; p is in shadow if d_light > d_blocker

Issues: resolution of the shadow map image? No soft shadows.

AMBIENT OCCLUSION



$$AO(\mathbf{p},\mathbf{n}) = \frac{1}{\pi}\int_{\Omega} V(\mathbf{p},\omega)\,\mathbf{n}\cdot\omega\,d\omega,$$



http://www.redway3d.com/

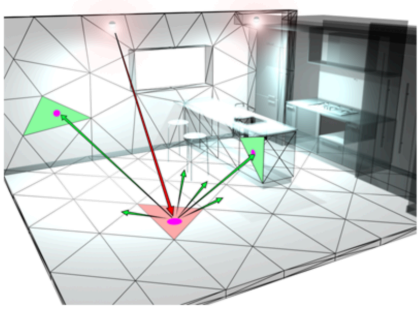
Assume that light is coming from all directions.
For a given point, compute the area of the surrounding hemisphere that is open.
Precompute and store this.

"RADIOSITY" METHOD FOR GLOBAL ILLUMINATION

Form factor F_ij: Fraction of light leaving surface i and arriving at surface j. This depends on the shape, distance, orientation, and relative occlusions of the two surface patches.

Solve a set of simultaneous linear equations for the unknown energies.

Assumes all surfaces are Lambertian, i.e., diffuse.
Requires subdivision of scene into patches.
The n^2 form factors are expensive to compute.



Radiosity: A ray of light that hits a surface is reflected by multiple diffuse rays, which can themselves illuminate other surfaces. Surfaces are subdivided to increase accuracy of the solution.

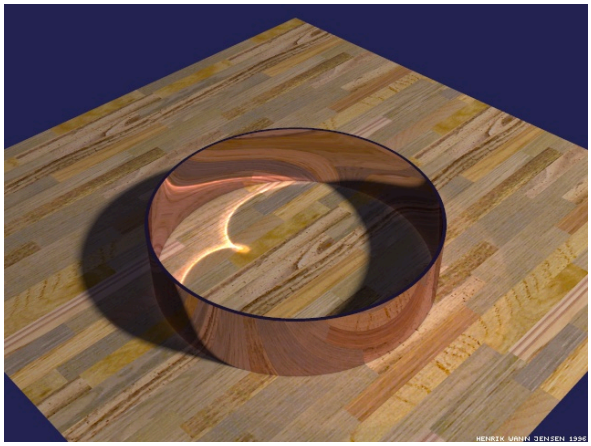
LIGHT BAKING

- precompute and “bake” into texture: static lighting of diffuse surfaces

[https://blogs.unity3d.com/2017/03/31/]

PHOTON MAPPING

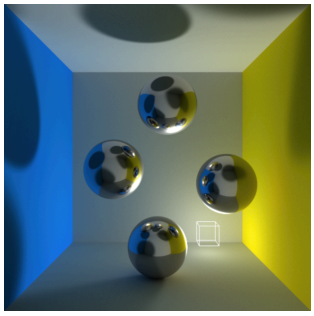
- trace light paths, “photons”, forward into scene, until they strike a diffuse surface.
- store locations and incoming directions of photons on the diffuse surface.
- efficient rendering of “caustics”

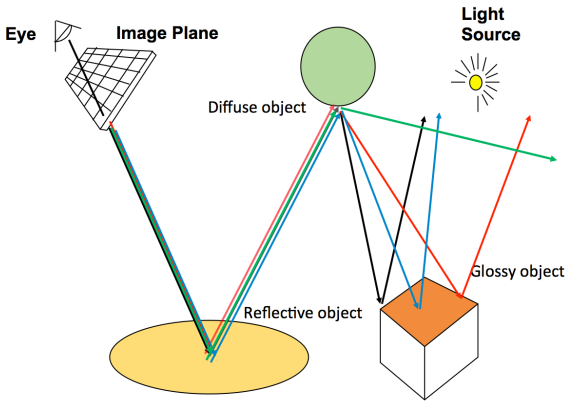


[Henrik Wann Jensen]

PATHTRACING

- global illumination
- trace paths from eye into scene
- Monte-Carlo sampling of directions
- multiple diffuse bounces
- average many sample rays per pixel
- "noisy" images with few samples
  - ML with deep nets to remove noise





RAY TRACING VS PATH TRACING

- Global illumination algorithms
- Rays emitted FROM camera

- Ray Tracing
  - Single ray per pixel
  - Supports indirect lighting only from specular surfaces
    - No color bleeding
  - Shoots shadow rays to compute direct illumination
    - Soft shadows are harder to get

- Path Tracing (*may produce renders indistinguishable from photos)*
  - Many rays per pixel, their color averaged
  - At each interaction, ray direction changes randomly with some distribution
  - No difference between light sources and objects
    - Soft shadows, complex materials, etc.
    - Supports all sorts of indirect lighting

COURSE SUMMARY

- affine transformations: change-of-basis, trans/rot/scale, composition
- view frustum, projection transformations, homogeneous coordinates
- explicit / implicit / parametric representations
- scan conversion, barycentric coordinates, interpolation using shaders
- clipping, view-frustum culling, back-face culling, occlusion culling, z-buffer visibility
- texture mapping, MIPMAPs, cubemaps, procedural textures
- Phong local illumination, raytracing, physically-based rendering
- shadow maps, ambient occlusion, photon mapping, path tracing
- WebGL: three.js + GLSL shaders

LEARNING MORE

- CPSC 426: Computer Animation (Jan) [Michiel van de Panne]
  - motion notation systems, keyframing, interpolating splines
  - representing orientations, quaternions
  - characters: inverse kinematics, rigging / skinning
  - physics-based animation: particles, cloth, fluids, rigid-body motion, characters
  - data-driven animation: motion capture, motion warping, ML
  - visual effects production, facial animation, game animation
- CPSC 424: Geometric Modeling (2019/20) [Alla Sheffer]
- Directed Studies
- Graduate School
- online / books / projects / …

FUTURE OF GRAPHICS

- 3D content creation by all
- better capture: omnidirectional, HDR, 3D geometry
- ML in many places
- VR/AR/MR
- physics-based human models with movement skills
- ever more photorealism

FINAL EXAM

• Mon Dec 17, 12:00pm, 2.5h: LIFE 2201 (unofficial)
• covers all topics
• closed book

• will post practice questions for physically-based rendering
• will post old final exams
• will post extra office hours

HAPPY HOLIDAYS !