SHADOW MAPPING
Usually used with projective rendering

(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

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.

http://www.redway3d.com/
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.
$E_B = 100 + 0.5E_A$

$E_A = 0.5E_B$

$100 = E_B - 0.5E_A$

$0 = E_A - 0.5E_B$

$E_B = \text{energy arriving at B}$

$E_A = \text{energy arriving at A}$

$\begin{bmatrix} 100 \\ 0 \end{bmatrix} = \begin{bmatrix} -0.5 & 1 \\ 1 & -0.5 \end{bmatrix} \begin{bmatrix} E_A \\ E_B \end{bmatrix}$
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”
PATHTRACING

- global illumination
- trace paths from eye into scene
- Monte-Carlo sampling of directions diffuse surfaces
- average many sample rays per pixel
- “noisy” images with few samples
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
• clipping, view-frustum culling, back-face culling, occlusion culling, z-buffer visibility
• texture mapping, MIPMAPs, cubemaps, procedural textures
• Phong local illumination, raytracing, shadow maps, ambient occlusion, photon mapping, path tracing
• WebGL: three.js + GLSL shaders
LEARNING MORE  (UBC)

• SIGGRAPH 2018:  Vancouver Convention Centre, Aug 12-16
• CPSC 426:  Computer Animation  (2018/19) [Michiel van de Panne]
  • motion notation systems, keyframing, interpolating splines
  • representing orientations
  • characters:  inverse kinematics, rigging
  • 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
• Grad School  —  Dinesh Pai, Alla Sheffer, Michiel van de Panne, ??
FUTURE OF GRAPHICS

- 3D content creation by all
- ML for content generation
- VR/AR/MR
- physics-based human models
- ever more photorealism
FINAL EXAM

• Fri Apr 13, 3:30pm, 2.5h: Henry Angus (ANGU) 098 (unofficial)
• covers all topics; additional weight towards lighting, shaders
• will post old final exams
• will post extra office hours
HAVE A GREAT SUMMER!