Lighting and Shading (cont'd)

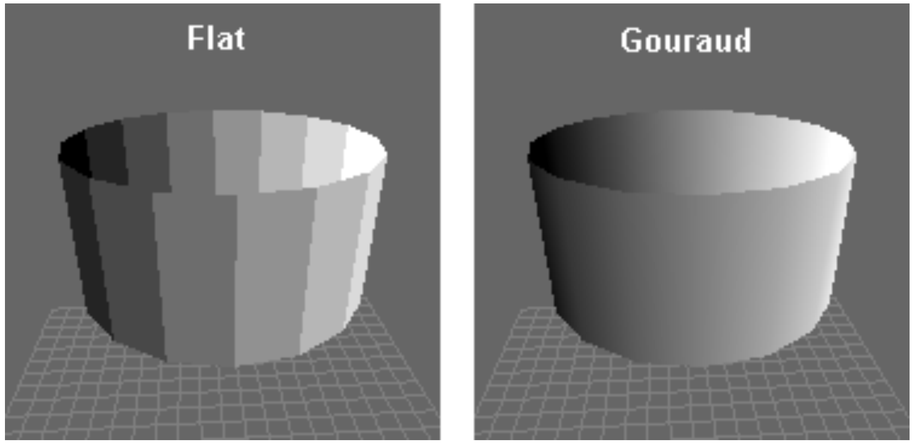
CS 355: Introduction to Graphics and Image Processing

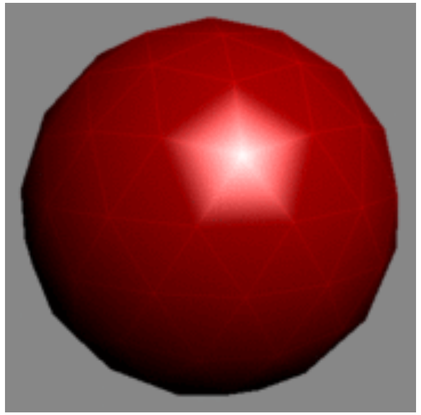
Flat Shading

- The entire polygon has the same normal, so it's all colored the same
- Leads to "flat shading"

Gouraud Shading

- Simple idea:
  - Compute shading at edges/ vertices and interpolate
  - Works well for diffuse
  - Doesn’t work as well for specular

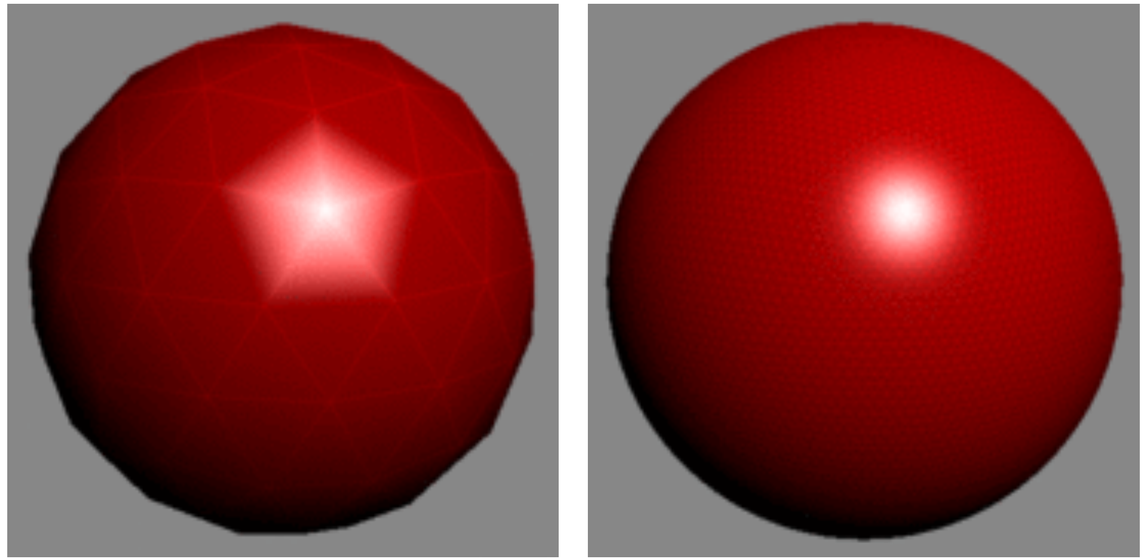




Henri Gouraud, 1971

Phong Shading

- Key idea:
  - Instead of interpolating the shading, *interpolate the normals*
  - Compute shading on a per-pixel basis using interpolated normal

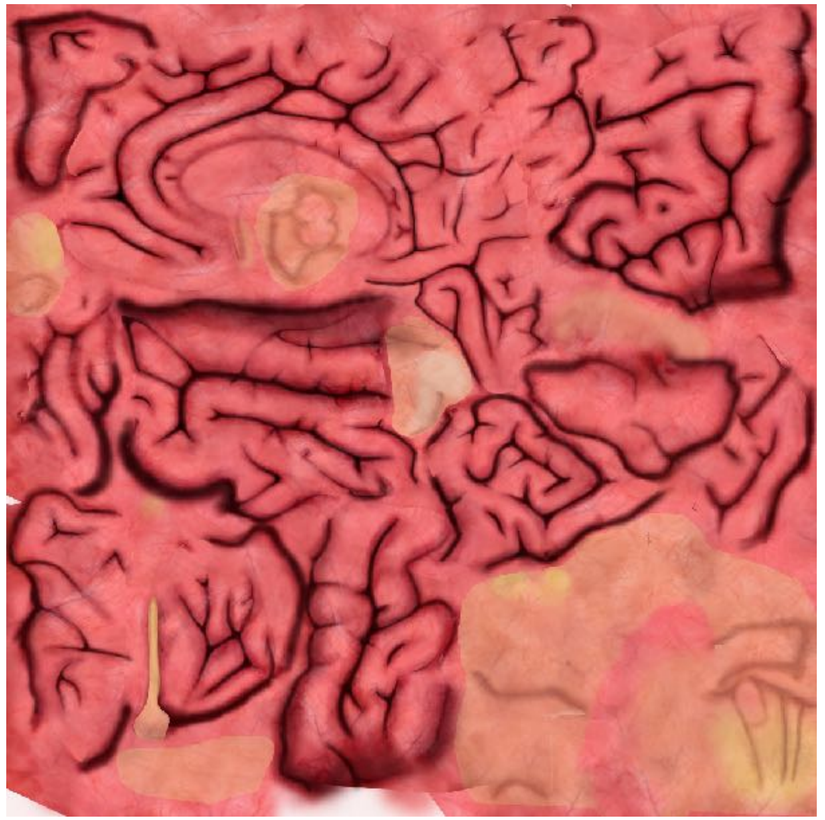


Bui Tan Phong, 1973

Texture Maps

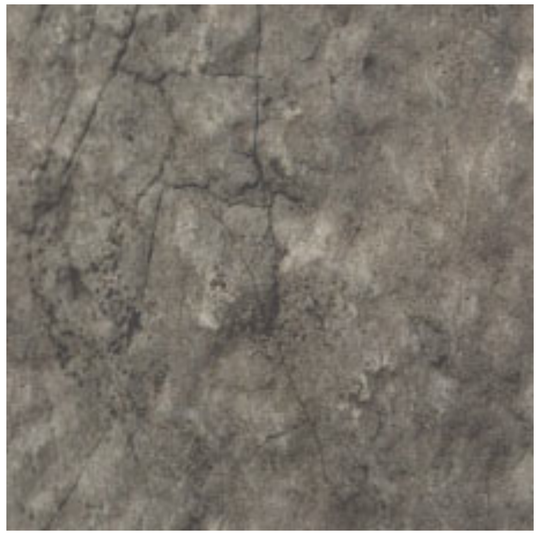
Texture Maps

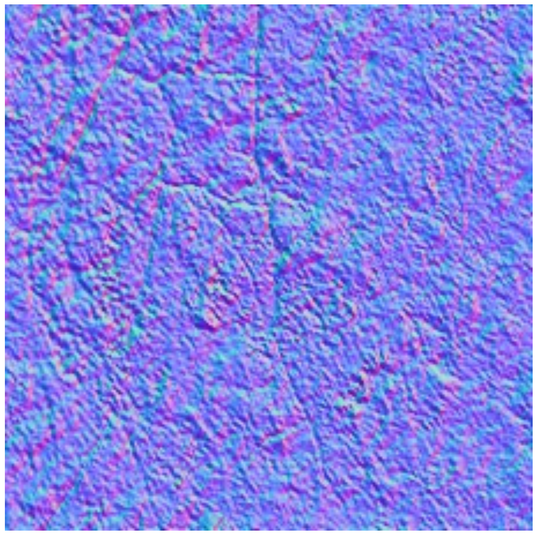
- Reflectance across a surface varies with position
- Map each vertex (x,y,z) to a point (u,v) in an image
- Interpolate across the polygon to interpolate the corresponding (u,v) positions in the image



Bump Maps

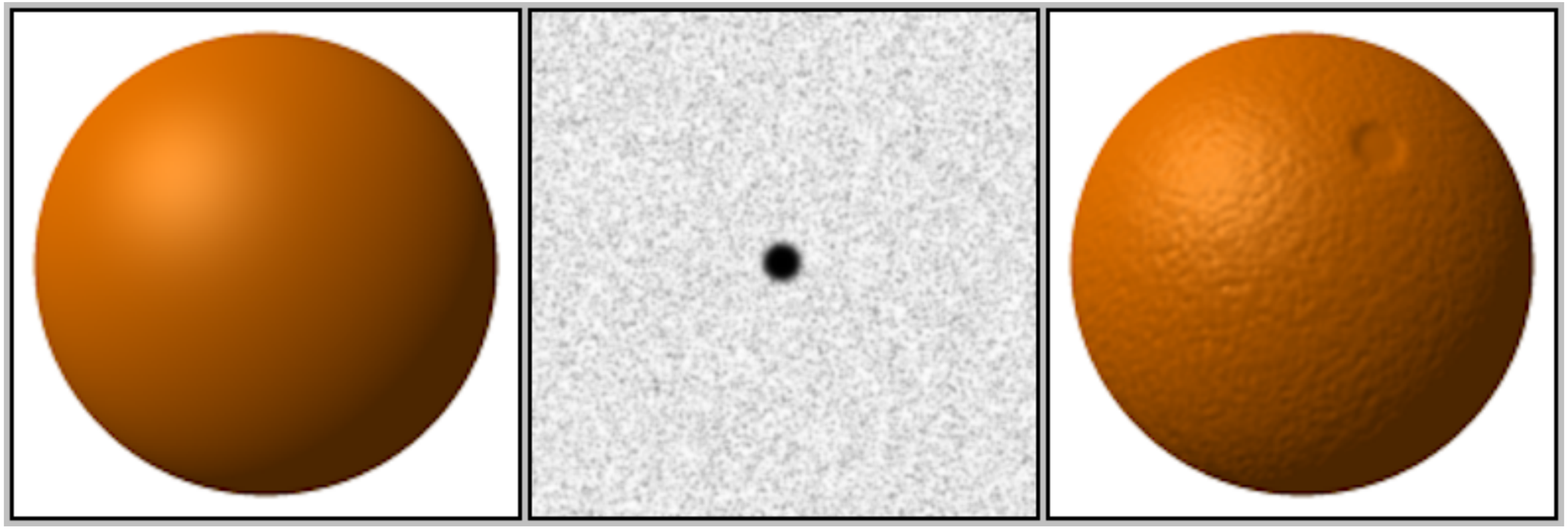
- Texture maps are only reflectance
- They don’t respond to changes in the lighting (“painted on”)
- Idea: use a *normal map*



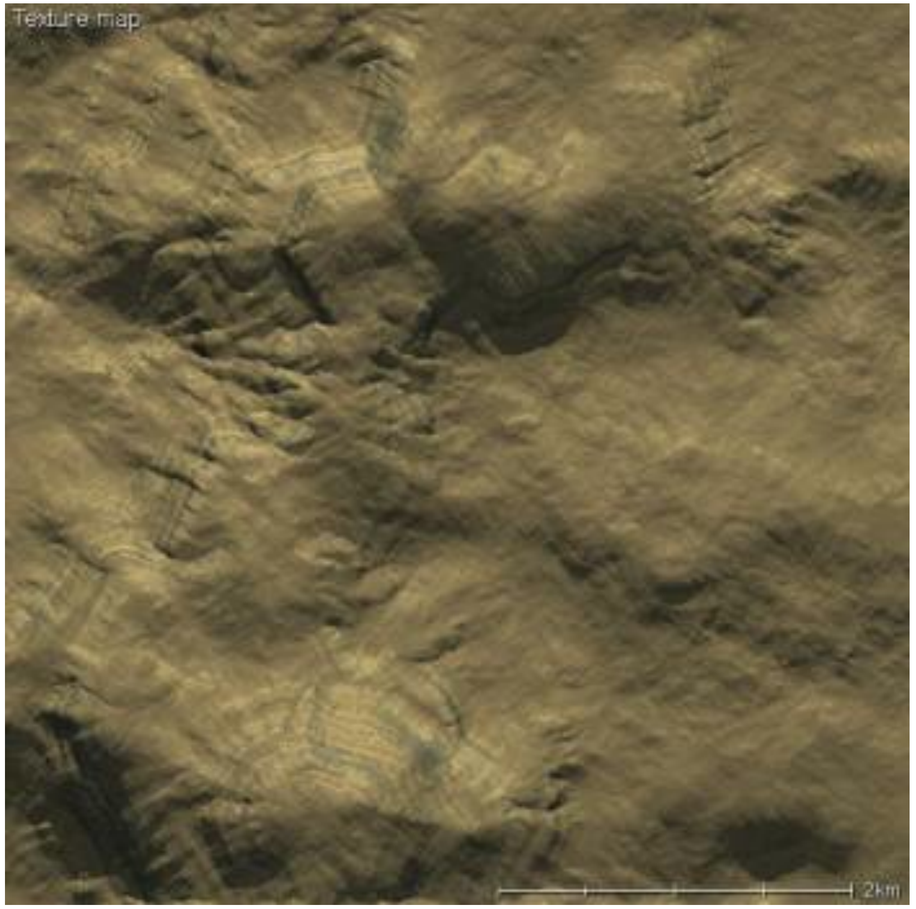


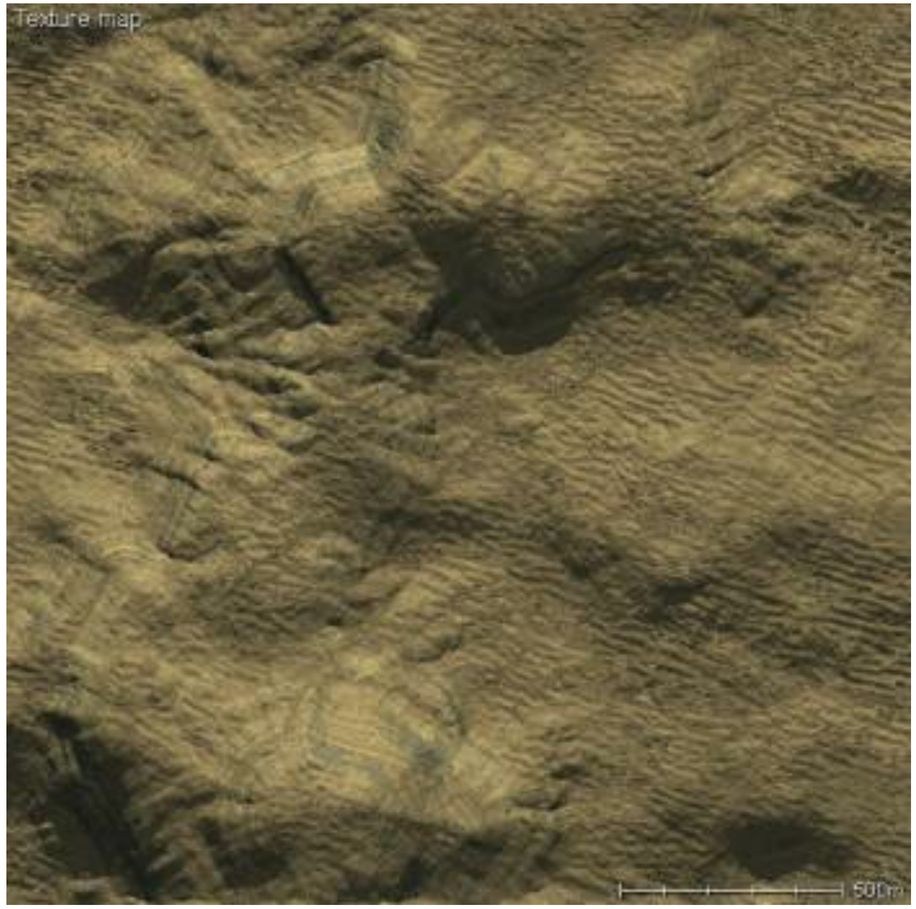
Jim Blinn, 1978

Bump Maps

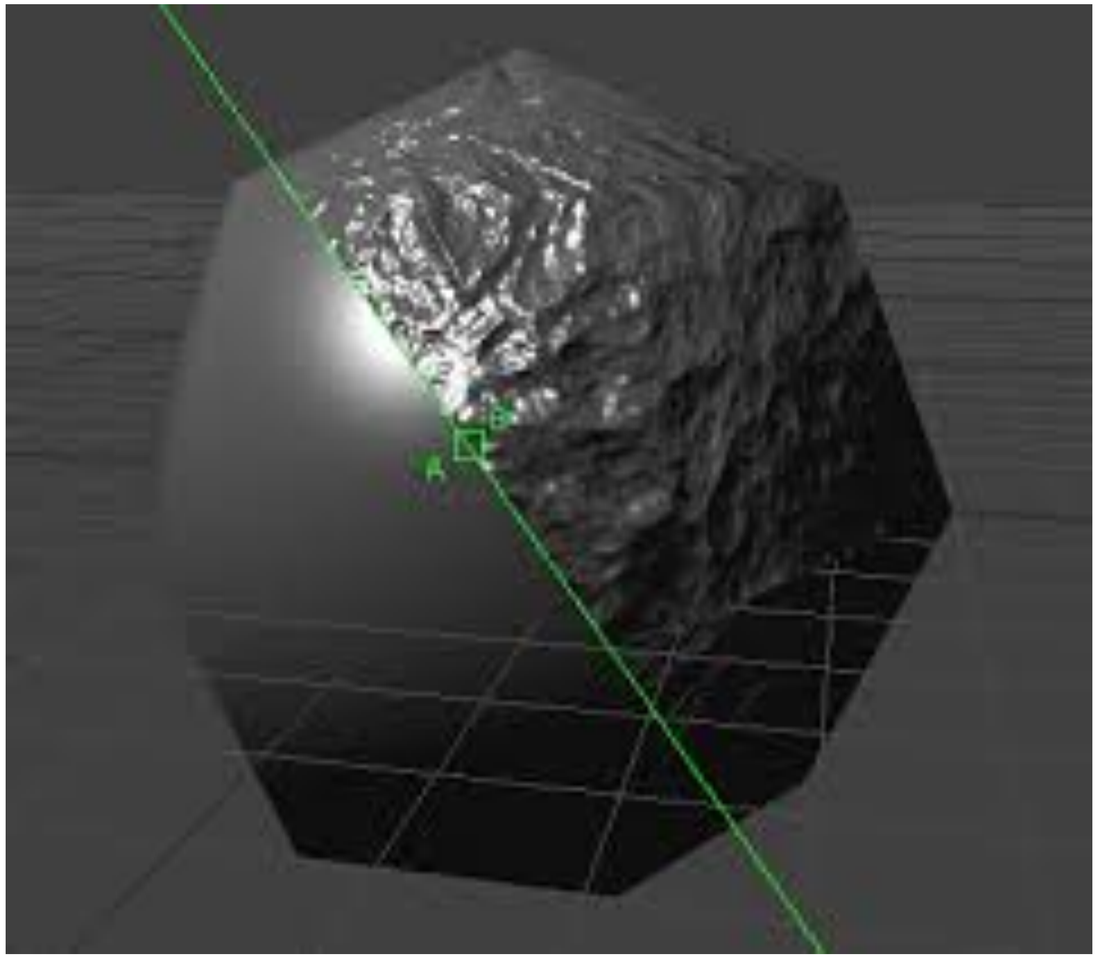


Bump Mapping

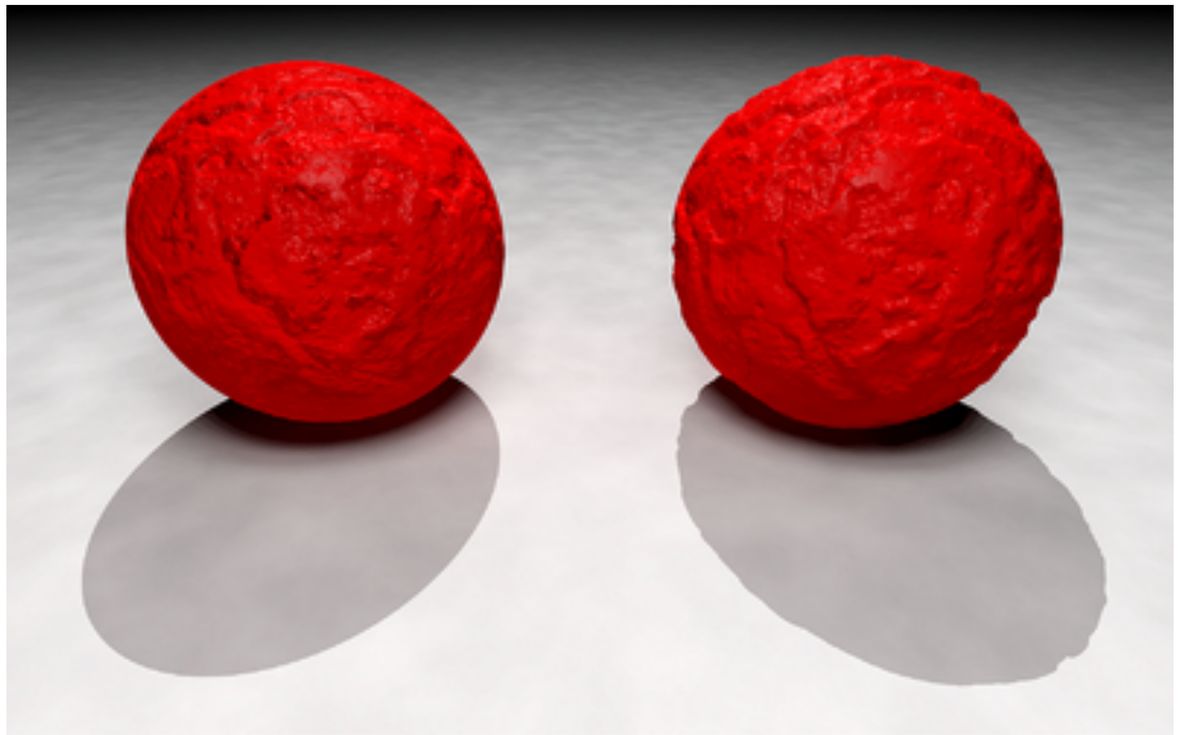




Bump Mapping



Bump Mapping

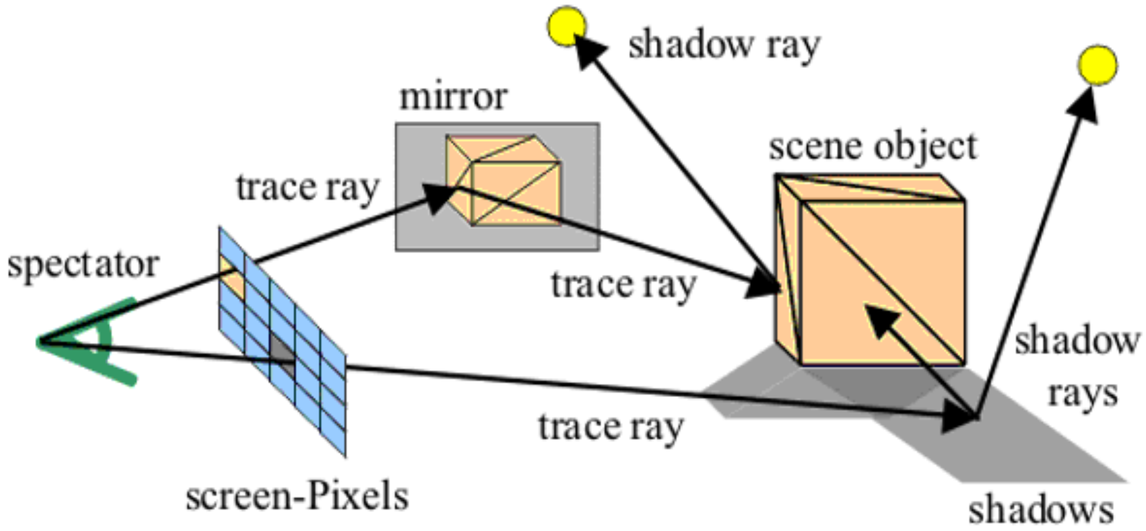


Ray Tracing

- What about things like
  - Reflections?
  - Refraction through transparent materials?

Ray Tracing

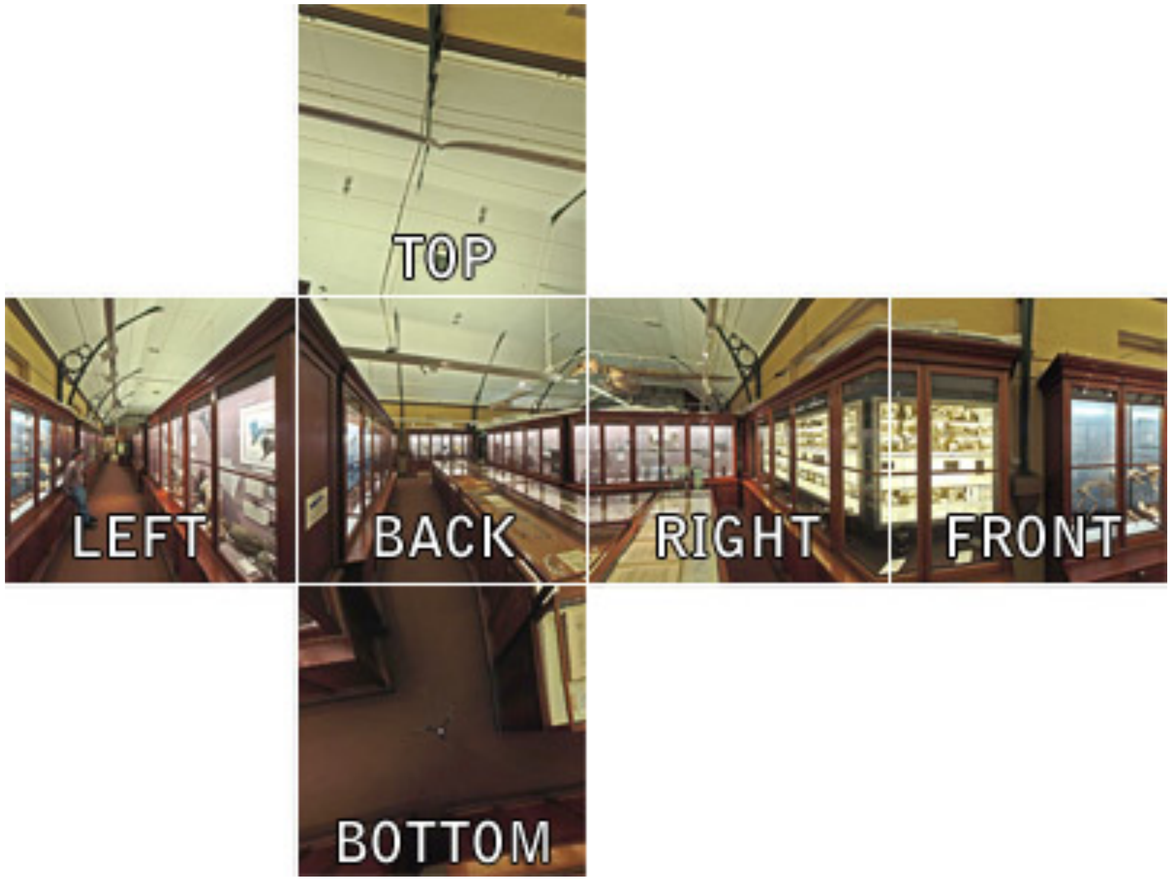
- Shoot a ray out through the pixel on the imaging plane
- When it hits something, ***recursively*** shoot more rays:
  - Towards light source(s) — direct lighting
  - Reflection ray (if applicable)
  - Refraction ray (if applicable)



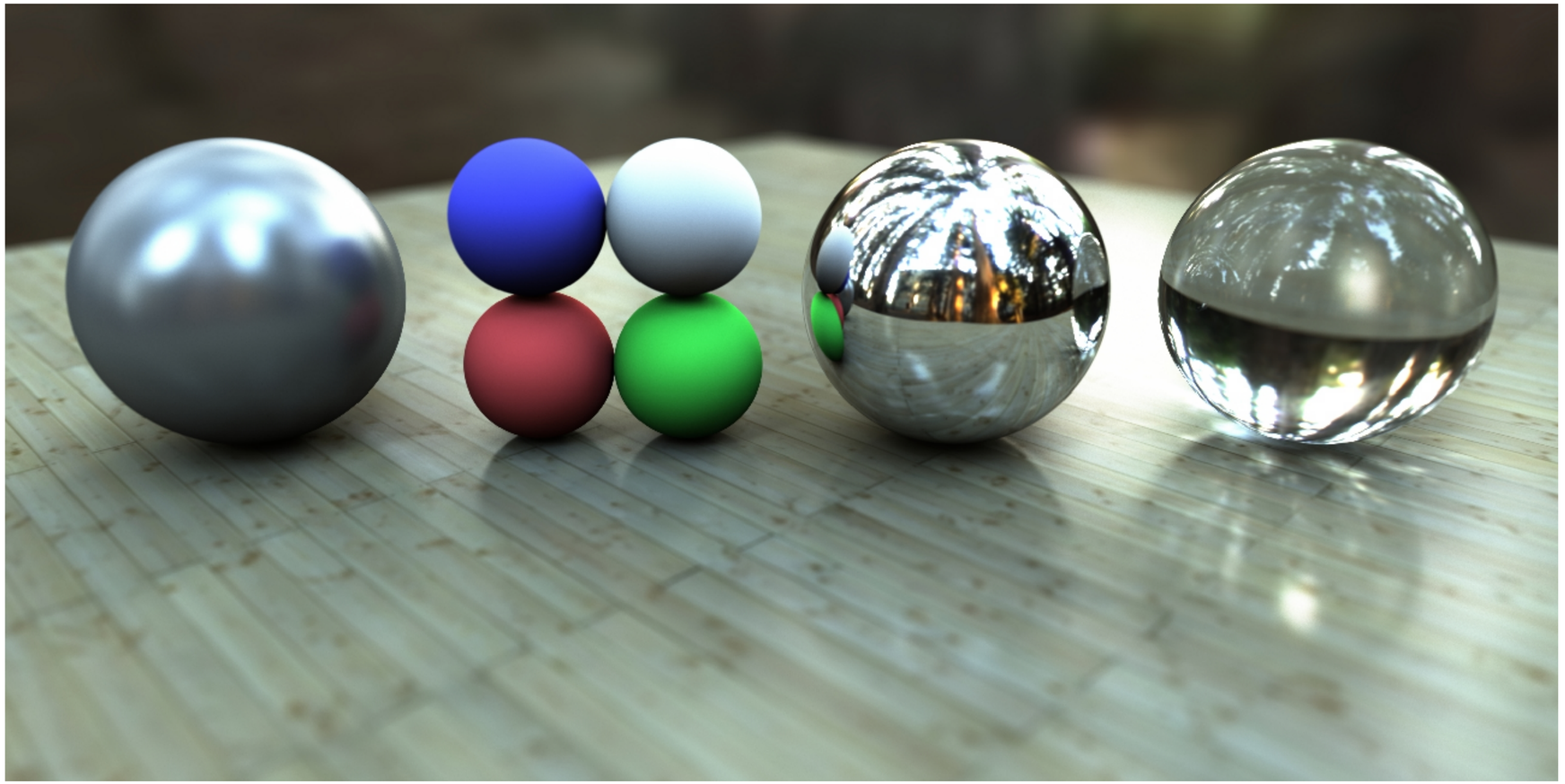
Turner Whitted, 1980

Environment Maps

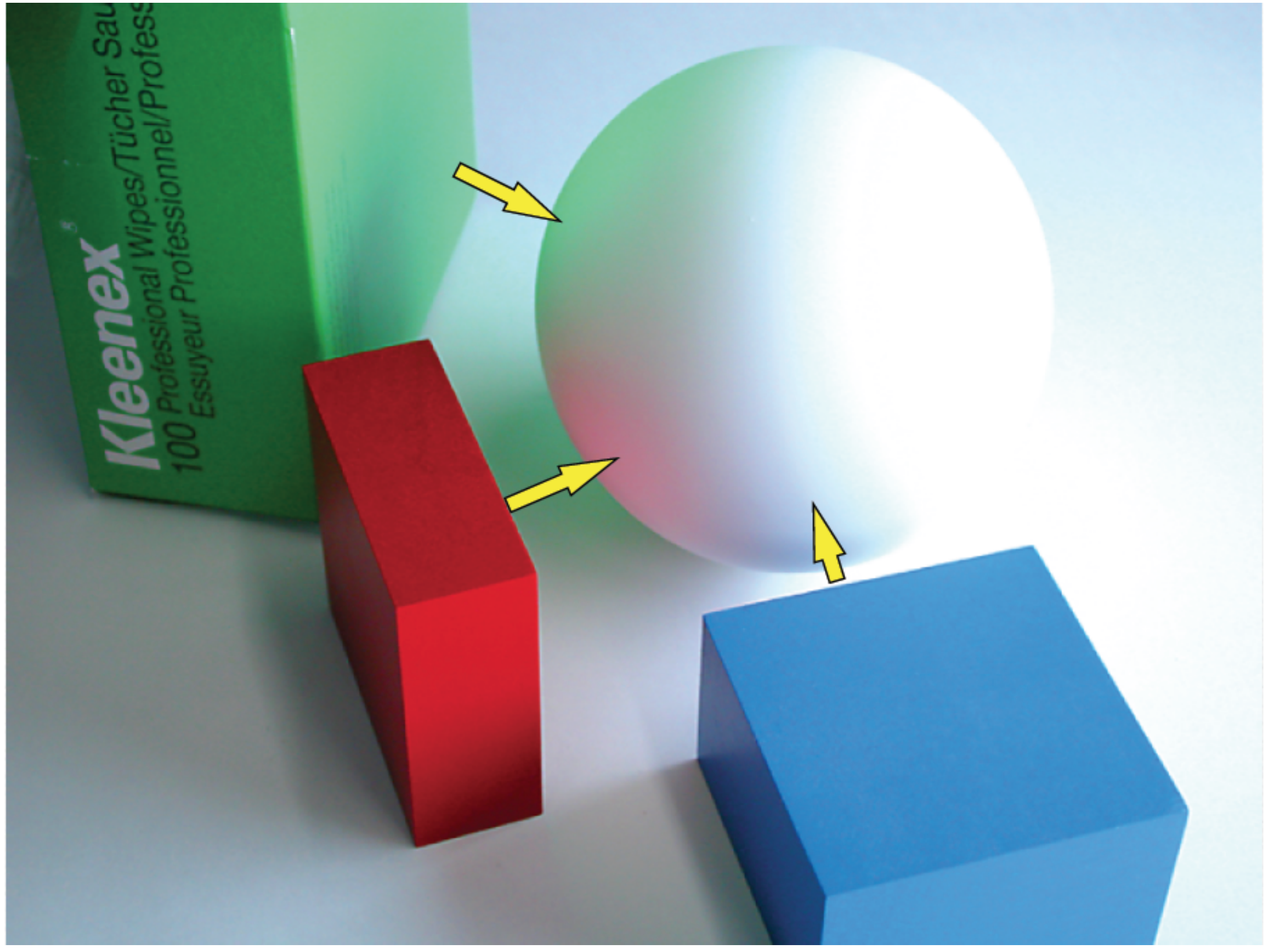
- What about rays that exit the scene?
- Can wrap the entire scene in an *environment map*
- Square, spherical, etc.



Environment Maps

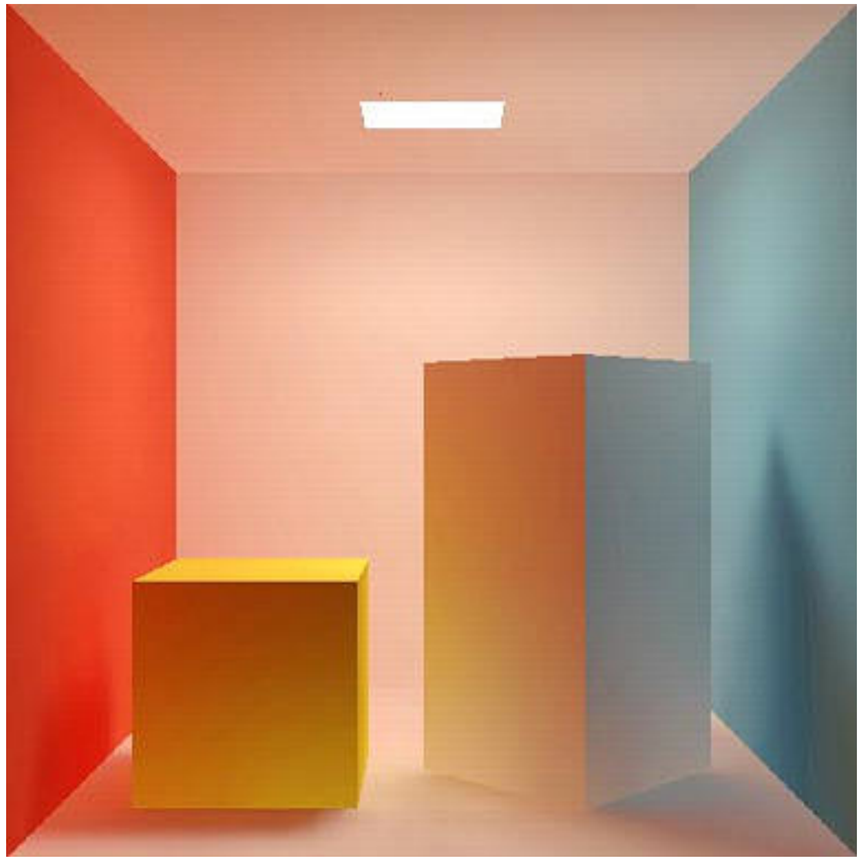


Diffuse Interreflections



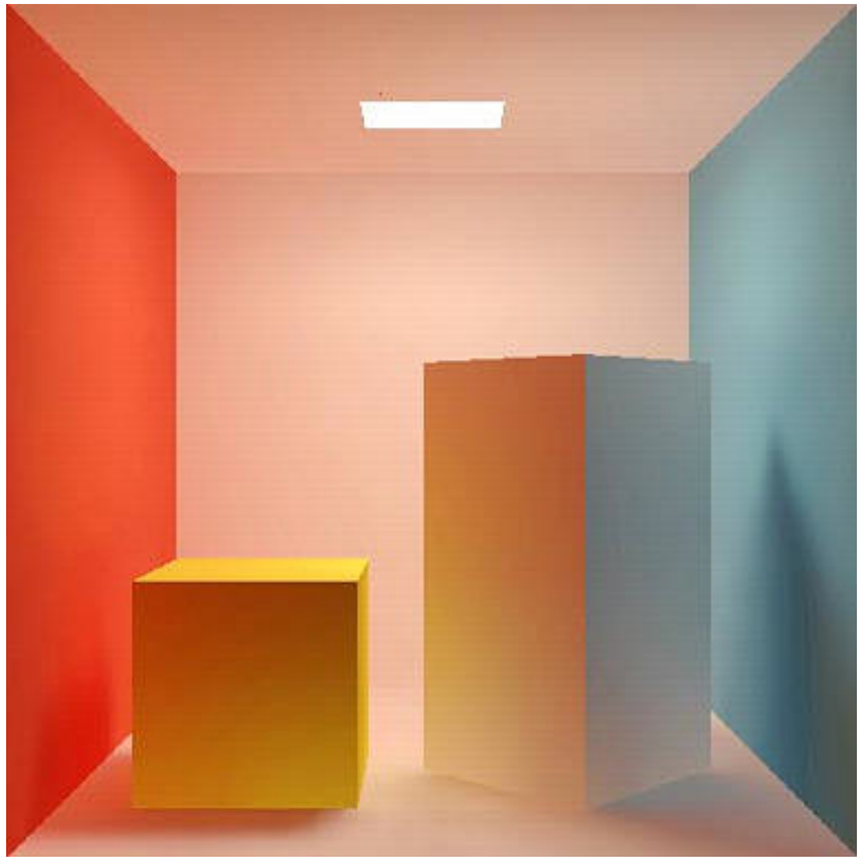
Radiosity

- Math involves integrals over *all angles* of light coming *into* and *off* of a surface
- Approximated using *importance sampling*
- Effectively traces lots and lots of rays — compute intensive



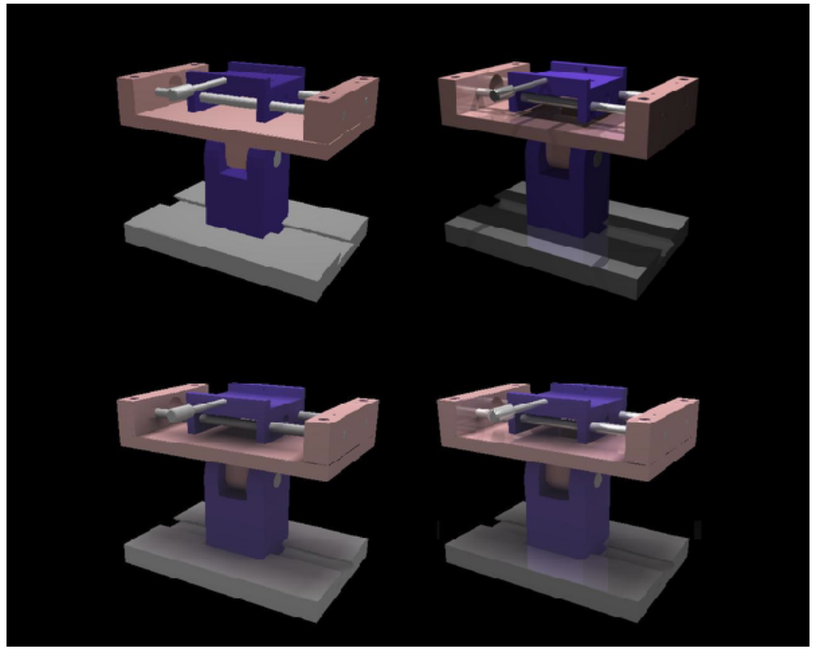
Radiosity

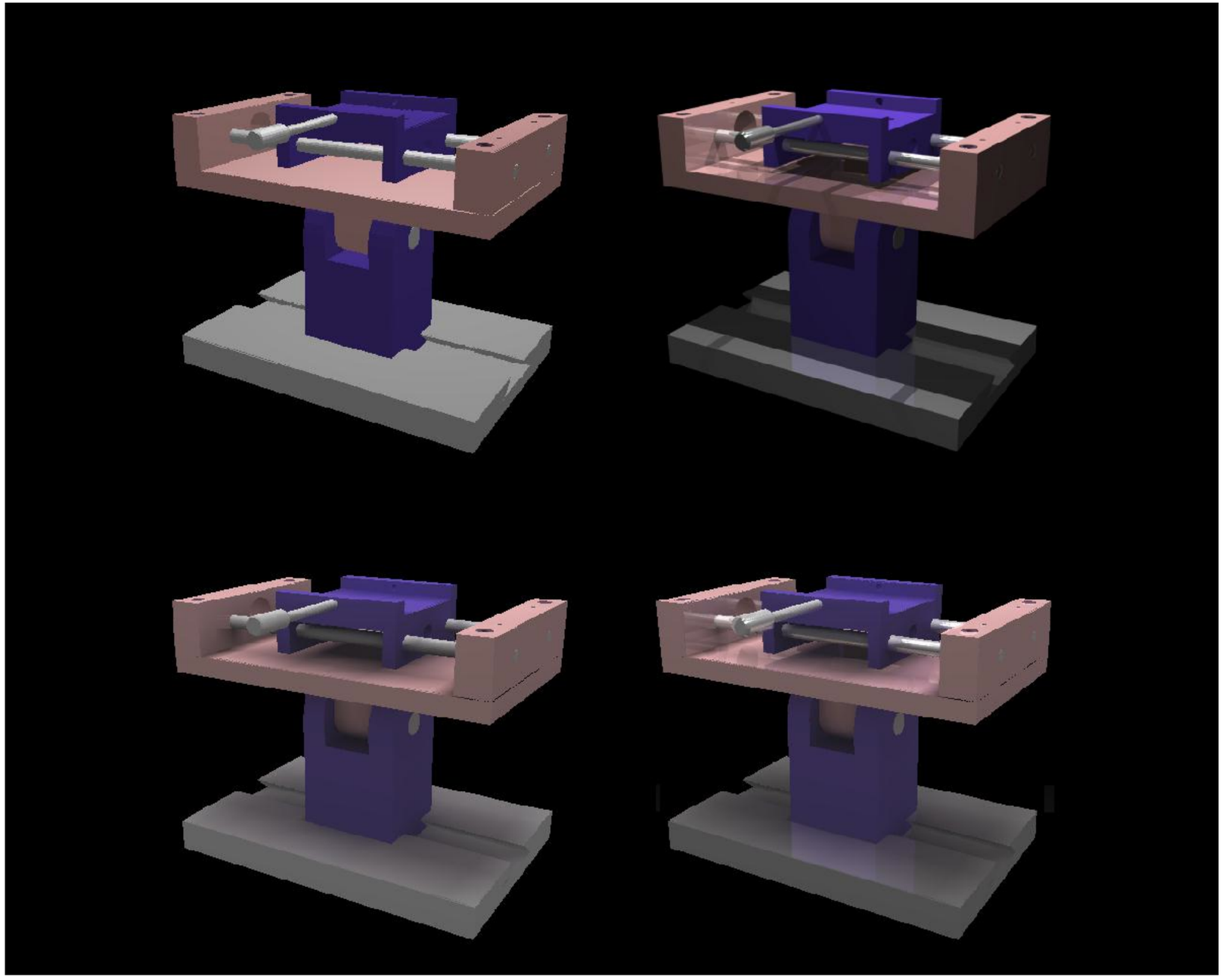
- Because radiosity involves diffuse light, it is independent of the viewpoint
- Can precompute ahead of time if objects and light sources *do not change*
- But if something other than the camera moves…



Combining Approaches

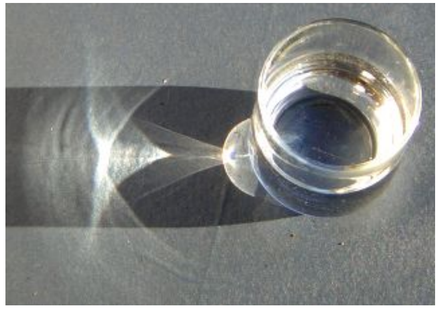
- Ray tracing is good for specular reflections, refraction, etc.
- Radiosity is good for diffuse interreflections
- Can combine methods to get both

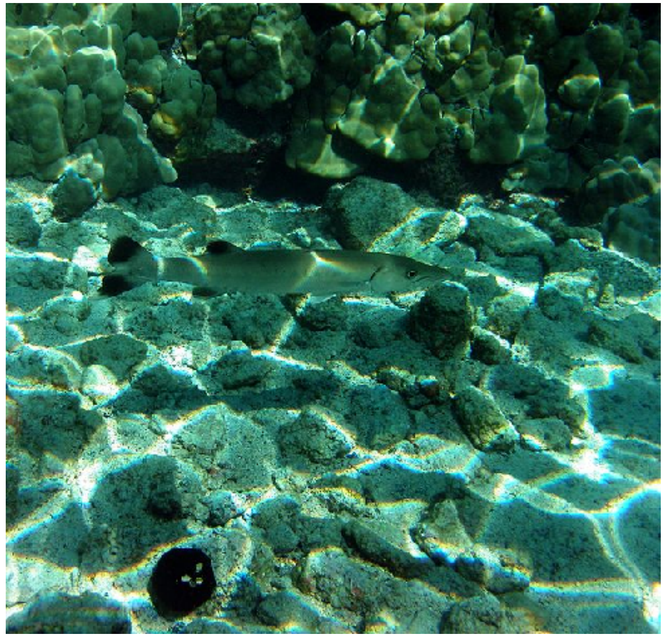




Forward Rendering

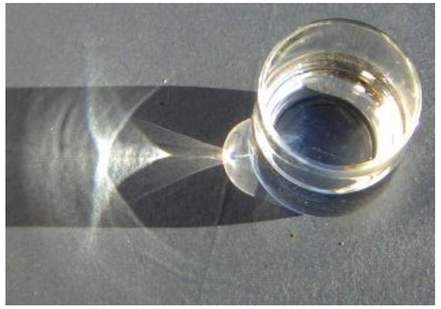
- Some phenomena can't be modeled well by going "backward" from the camera
  - ray tracing
  - radiosity
- Some require "forward" rendering of the light from the light source
- Example: "caustics"

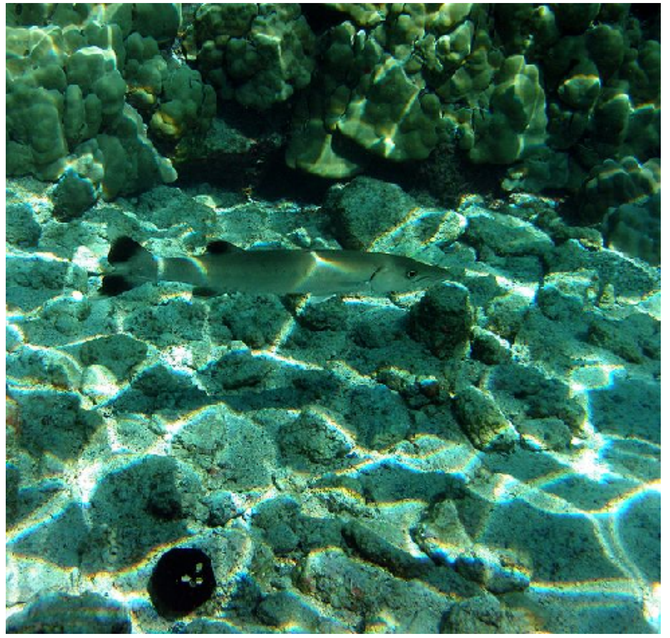




Forward Rendering

- Forward or hybrid methods:
  - Path tracing
  - Metropolis light transport
  - Photon mapping
- All try to *approximate* the "rendering equation" (Jim Kajiya, 1986)





More in CS 455…

- Ray tracing and variations
- Radiosity
- Other lighting models
- Curves and surface modeling
  (we'll talk a bit about this coming up)
- Animation (movement)
- Physical-based modeling
- And much more…

The Rest of the Semester…

- Physical cameras revisited
- Interpolation
- Image warping
- A bit more geometry…
- Curves and surfaces
- Frequency-domain processing