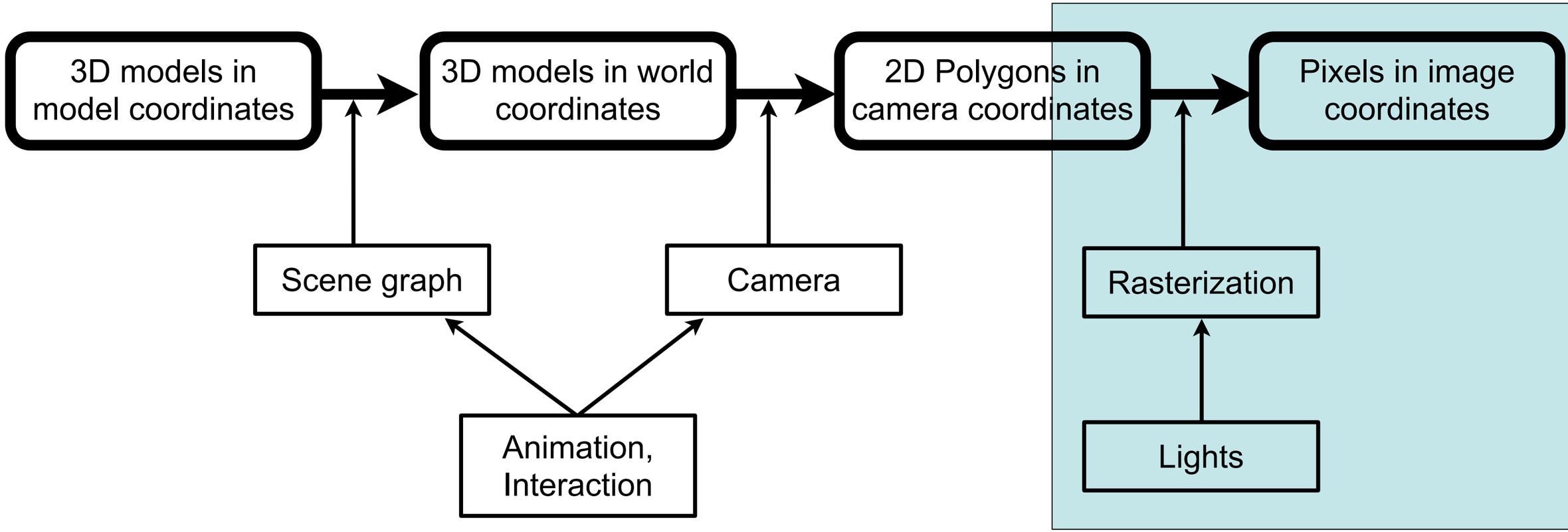
Computer Graphics 1

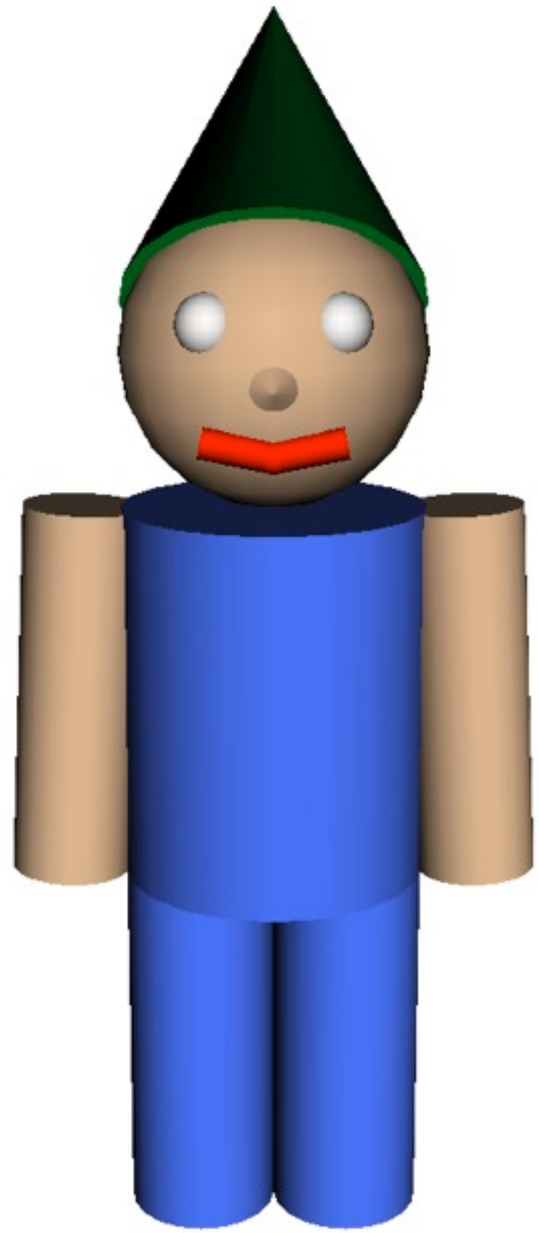
Chapter 7 (June 17th, 2010, 2-4pm):
Shading and rendering

The 3D rendering pipeline (our version for this class)



Local Illumination: Shading

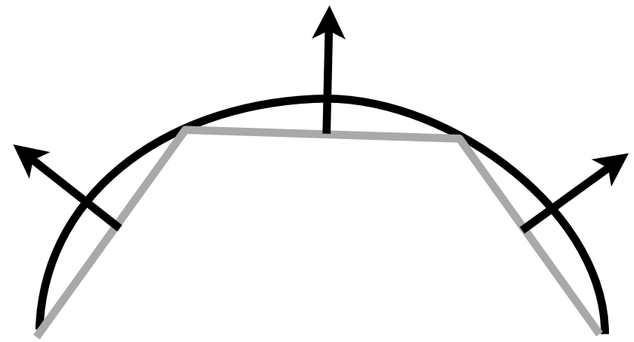
- Local illumination:
  - light calculations are done locally without the global scene
  - no cast shadows (since those would be from other objects, hence global)
  - object shadows are OK, only depend on the surface normal



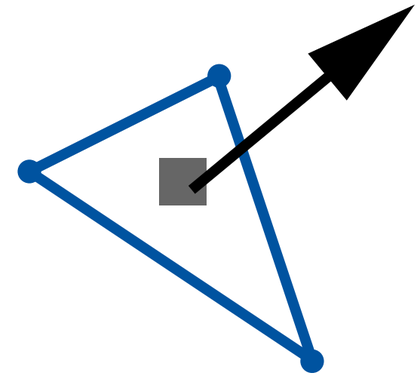
- Loop over all polygons
- For each polygon:
  - determine the pixels it occupies on the screen and their color
  - draw using e.g., Z-buffer algorithm to get occlusion right

- Each polygon only considered once
- Each pixel considered multiple times

Flat shading



- Determine one surface normal for each triangle
- Compute the color for this triangle
  - using e.g., the phong illumination model
  - using the normal, camera and light positions
- Draw the entire triangle in this color

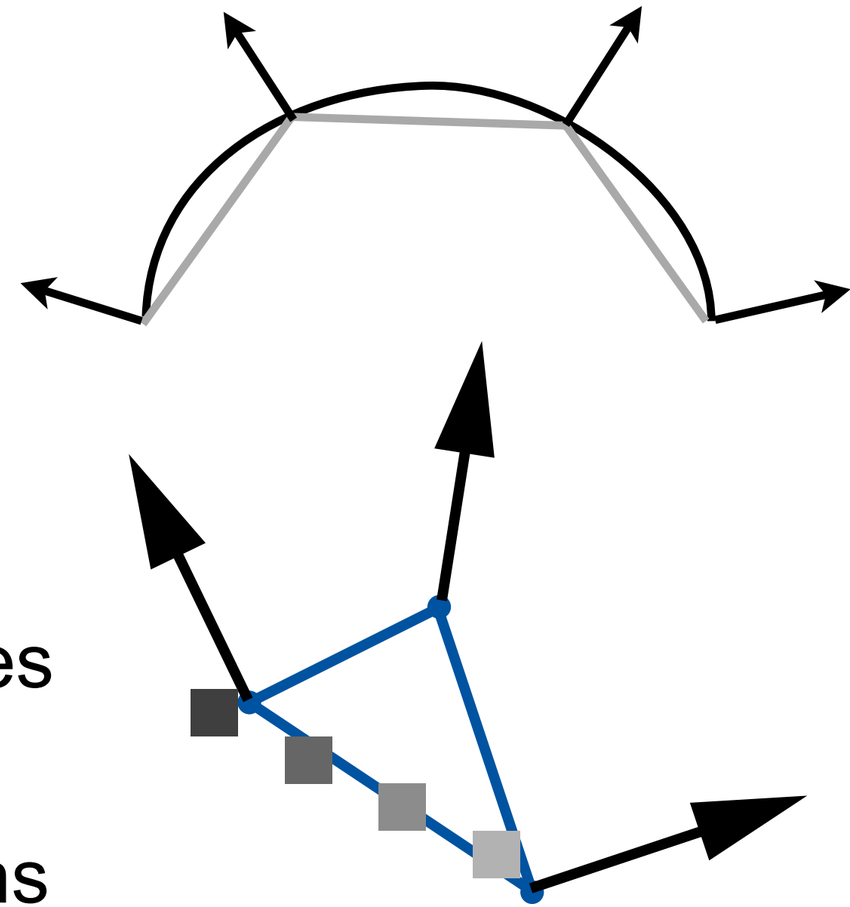


- neighboring triangles will have different shades
- visual „crease“ between triangles

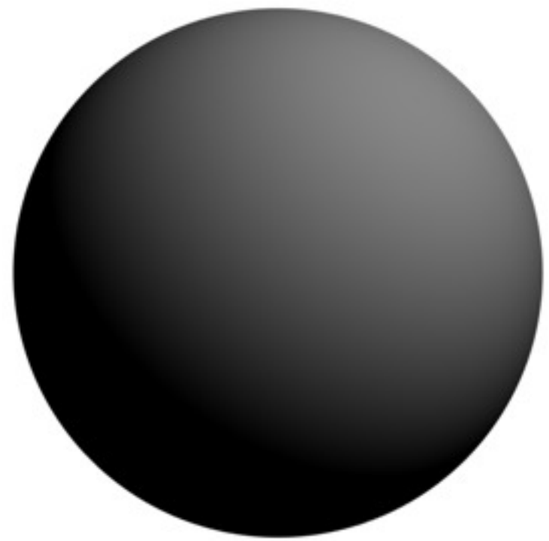
- cheapest and fastest form of shading
- can be a wanted effect, e.g. with primitives

Gouraud shading

- Determine normals for all mesh vertices
  - i.e., triangle now has 3 normals
- Compute colors at all vertices
  - using e.g., the phong illumination model
  - using the 3 normals, camera and light positions
- Interpolate between these colors along the edges

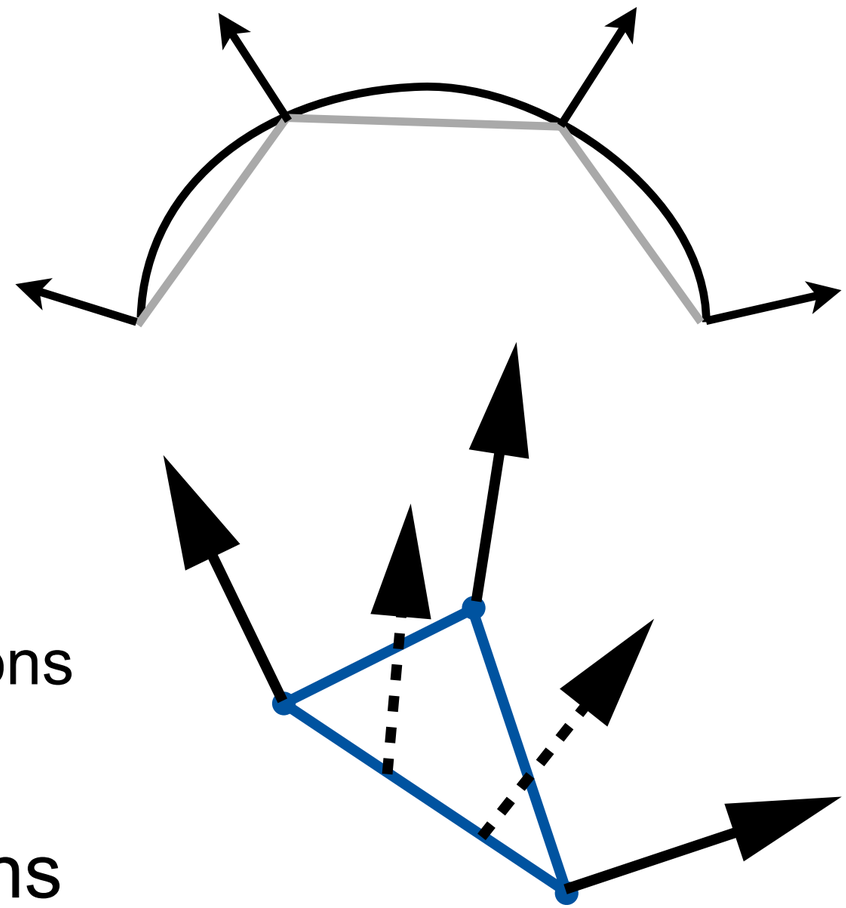


- neighboring triangles will have smooth transitions
  - if normals at a vertex are the same for all triangles using it
- simplest form of smooth shading
  - specular highlights only if they fall on a vertex by chance



Phong Shading

- Determine normals for all mesh vertices
- Interpolate between these normals along the edges
- Compute colors at all vertices
  - using e.g., the phong illumination model
  - using the interpolated normal, camera and light positions

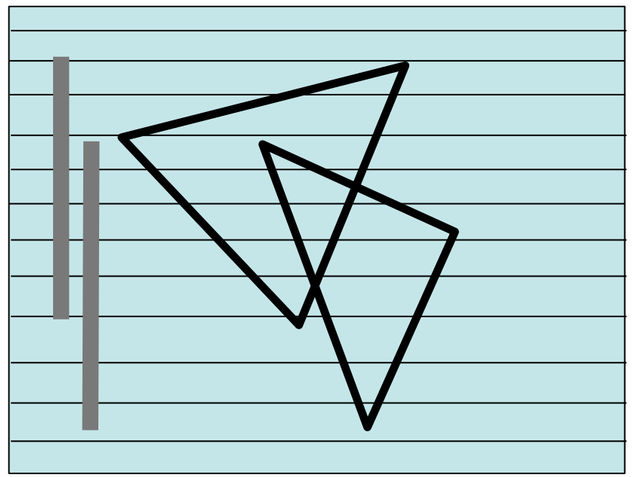


- neighboring triangles will have smooth transitions
  - if normals at a vertex are the same for all triangles using it

- has widely substituted gouraud shading
  - specular highlights in arbitrary positions
  - have to compute phong illumination model for every pixel

Scan-line algorithms

- Sort all polygons by their top Y position in the image
- Scan through the image line by line
  - load polygons which start there into memory
  - discard polygons that have ended on the scan line before
- Draw all polygons currently loaded
  - sort from left to right by intersecting edges with scan line
  - using appropriate depth calculation (e.g., Z-Buffer)
  - using appropriate lighting (e.g., phong illumination model)
- Only a small number of polygons considered in each line
  - good for optimizing memory access and caching



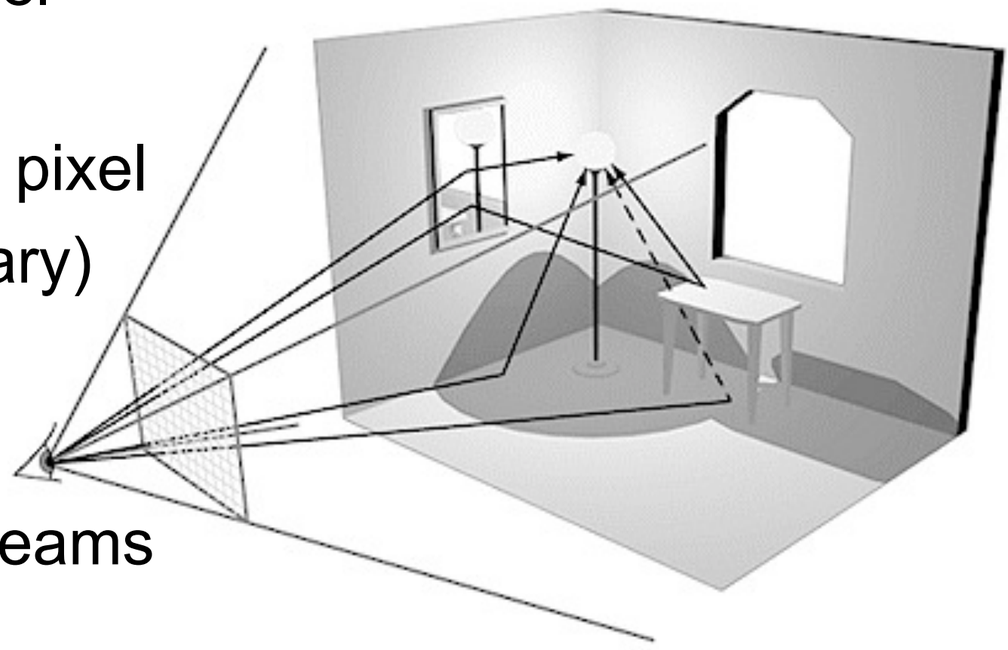
- Each polygon only considered once
- Each pixel considered only once

Global illumination: Ray tracing

- Global illumination:
  - light calculations are done globally considering the entire scene
  - i.e. cast shadows are OK if properly calculated
  - object shadows are OK anyway

- Ray casting:
  - from the eye, cast a ray through every screen pixel
  - find the first polygon it intersects with
  - determine its color at intersection and use for the pixel
  - also solves occlusion (makes Z-Buffer unnecessary)

- Ray tracing: recursive ray casting
  - from intersection, follow reflected and refracted beams
  - up to a maximum recursion depth



http://pclab.arch.ntua.gr/03postgra/mladenstamenico/ (probably not original)

http://hof.povray.org/glasses.html

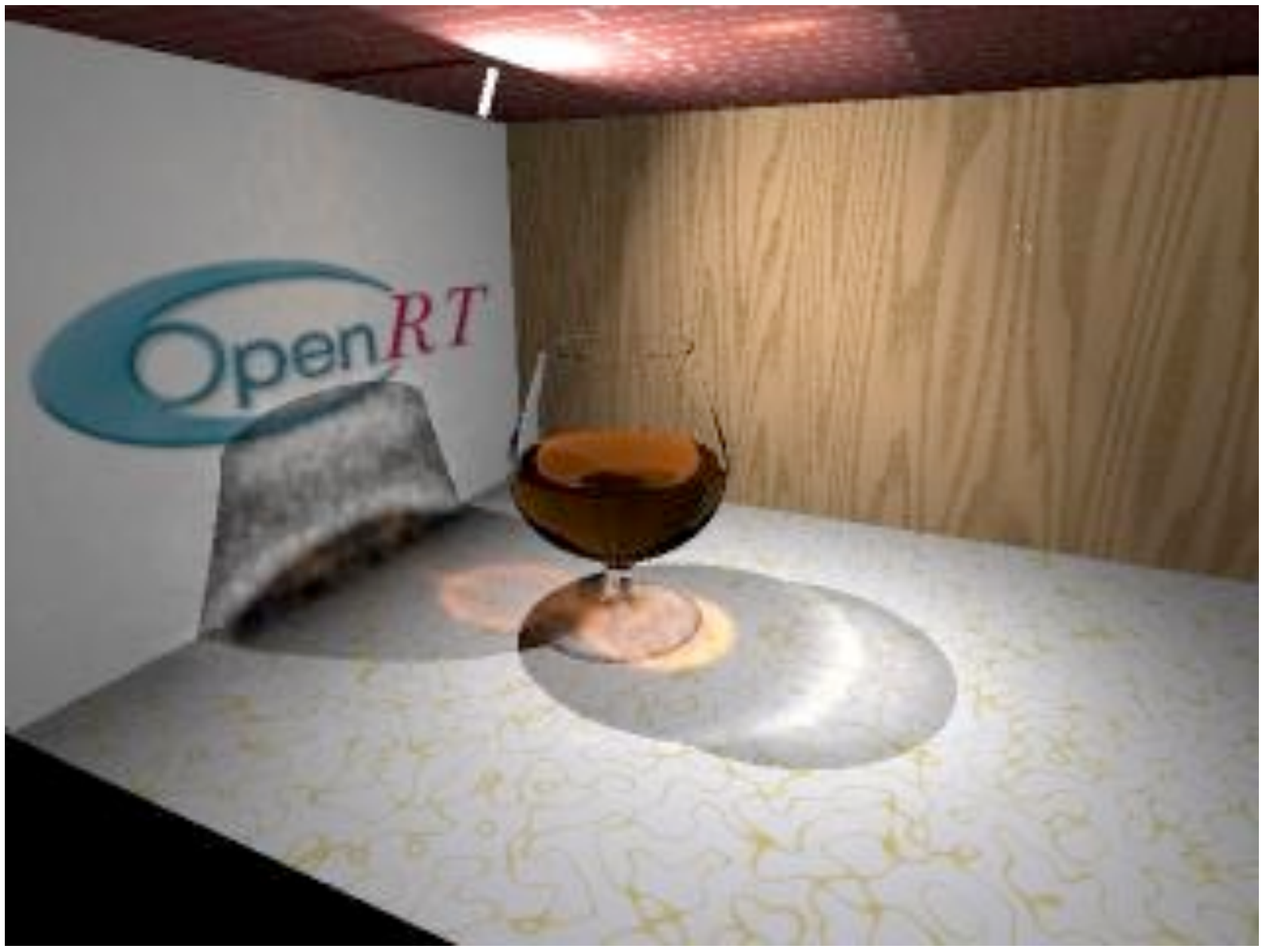
source: Blender Gallery

source: Blender Gallery

Brainstorming: what makes Ray Tracing hard?

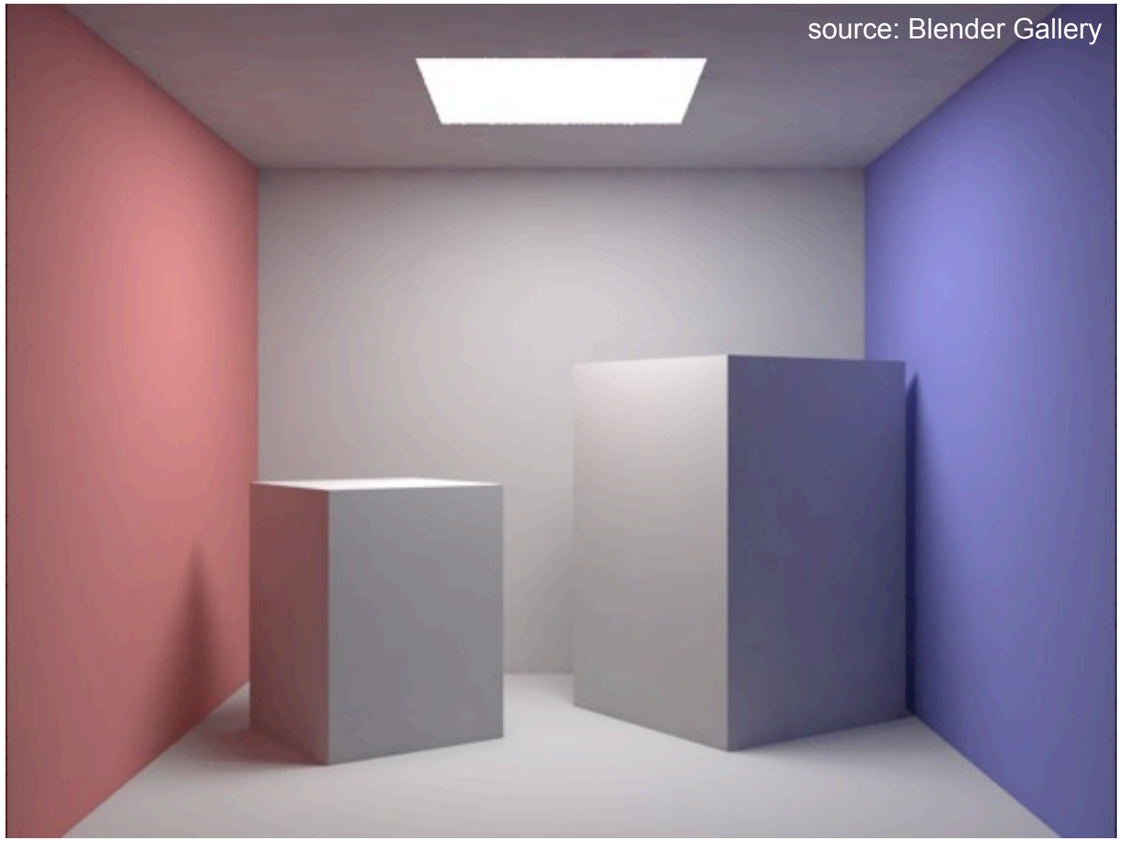
Recent development: Real Time Ray Tracing

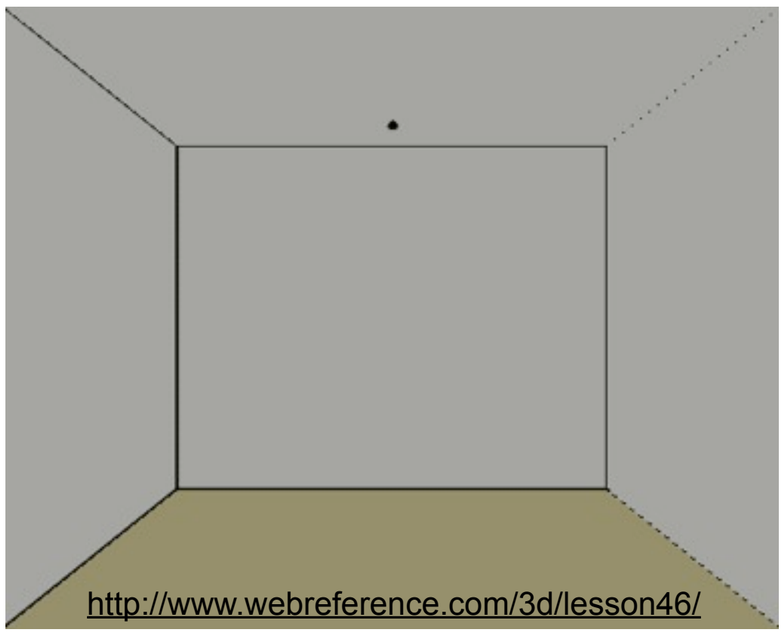
- Various optimizations presented over the last few years
- Real time ray tracing has become feasible
- Follow http://openrt.de/ (images from there)



Global illumination: Radiosity

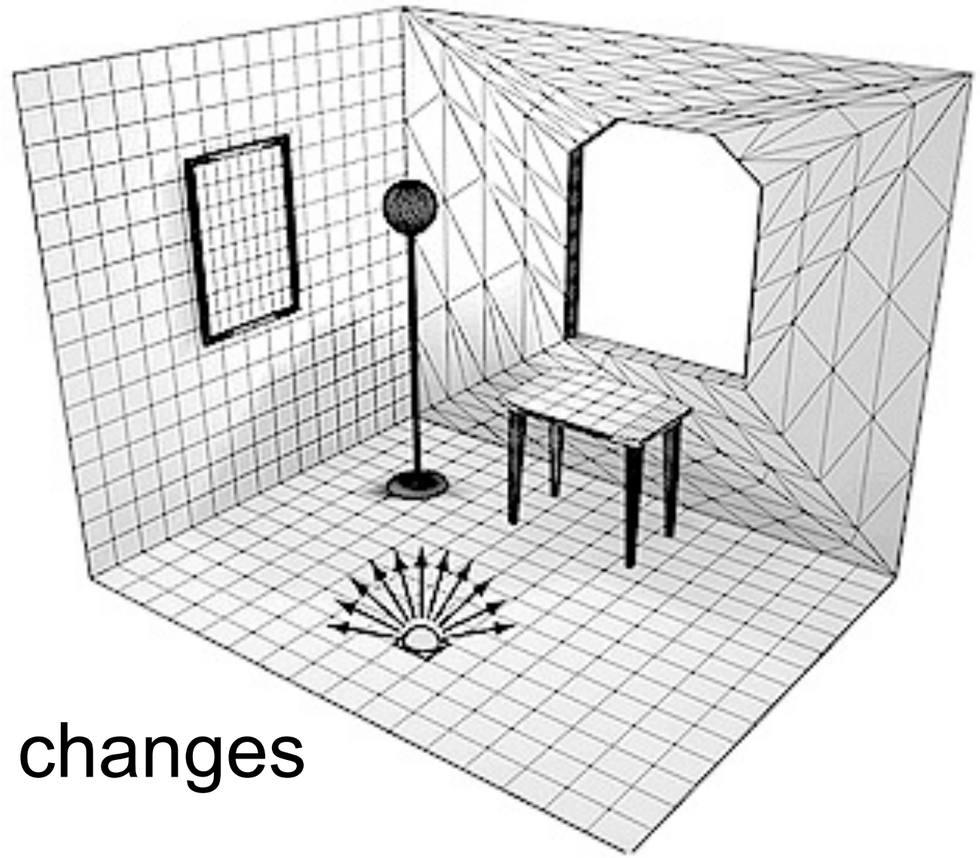
- Simulation of energy flow in scene
- Can show „color bleeding“
  - blueish and reddish sides of boxes
- Naturally deals with area light sources
- Creates soft shadows
- Only uses diffuse reflection
  - does not produce specular highlights





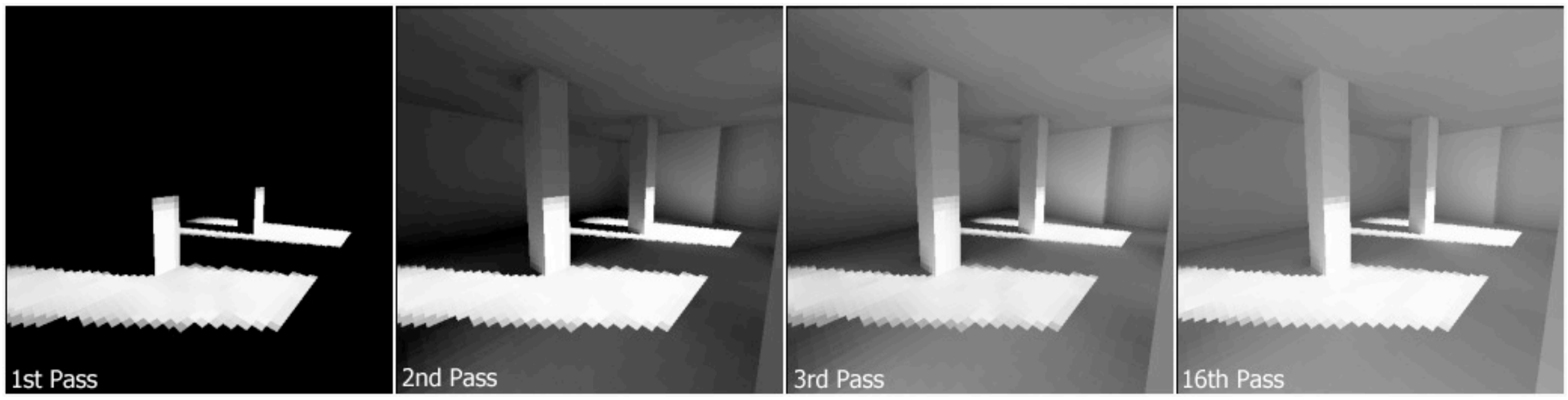
Radiosity algorithm

- Divide all surfaces into small patches
- For each patch determine its initial energy
- Loop until close to energy equilibrium
  - loop over all patches
    - determine energy exchange with every other patch
- „radiosity solution“: energy for all patches
- Recompute if _____ changes



http://pclab.arch.ntua.gr/03postgra/mladenstamenico/ (probably not original)

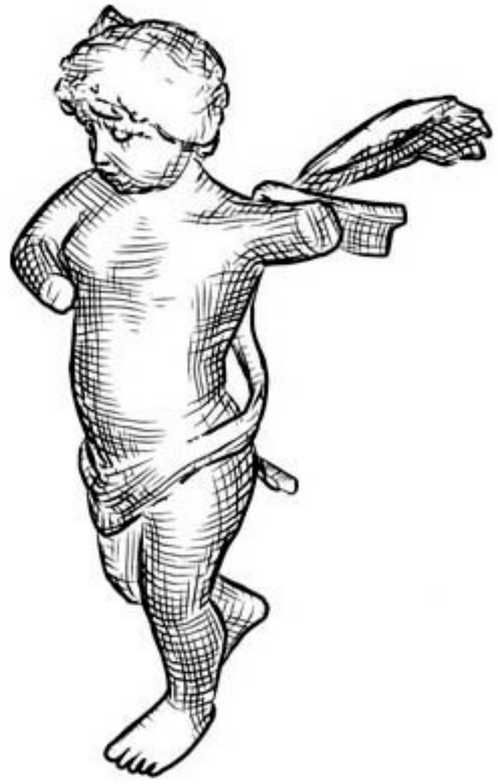
http://en.wikipedia.org/wiki/File:Radiosity_Progress.png



source: Blender Gallery

Non-Photorealistic Rendering (NPR)

- Create graphics that look like drawings or paintings



http://www.cs.ucdavis.edu/~ma/SIGGRAPH02/course23/

- One method: stroke-based NPR
  - instead of grey shades, determine a stroke density and pattern
  - imitates pencil drawings or etchings (Kupferstich)
- Other methods: using image manipulation on rendered images
  - can in principle often be done in photoshop
- Active field of research
  - http://www.cs.ucdavis.edu/~ma/SIGGRAPH02/course23/
  - http://graphics.uni-konstanz.de/forschung/npr/watercolor/
  - many others

http://www.katrinlang.de/npr/