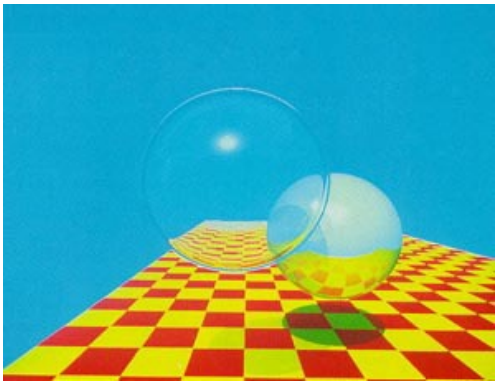
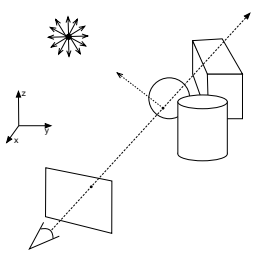
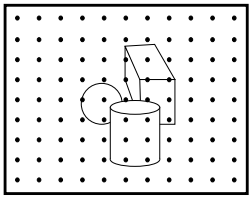
Ray Tracing 2



Aliasing

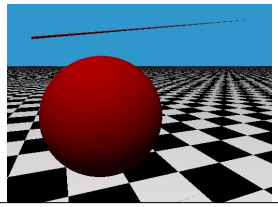
- ray tracing is inherently an image space algorithm (point sampling) -> jaggies

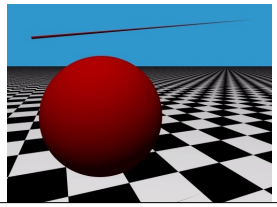




Supersampling

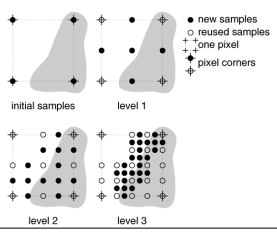
- what can be done?
  - increase sample rate
  - increase sample rate and average over several samples (supersample, oversample) to get pixel
- expensive

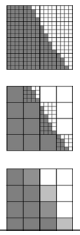


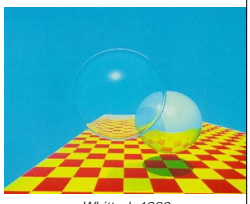


Adaptive Supersampling

- heuristic: adaptive supersampling
- increase sample rate only in “troublesome” regions
- if difference in neighbours > threshold
  - increase sample rate in neighbourhood



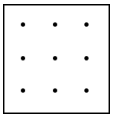


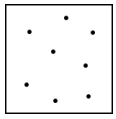


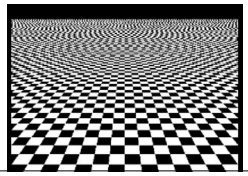
Whitted, 1980

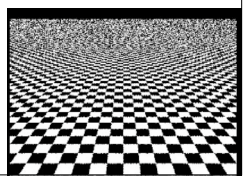
Non-uniform Sampling

- regular sampling pattern results in regular aliasing pattern
- non-uniform sampling results in noisy image
- noise less objectionable than regular aliasing pattern





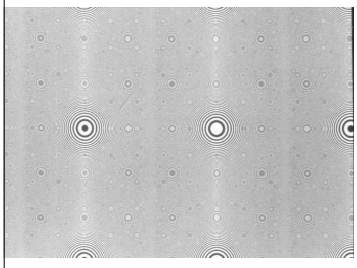


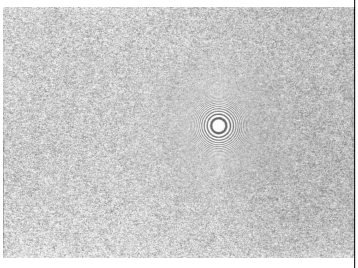


Cook 1984

Non-uniform Sampling

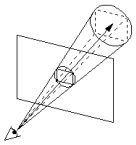
$\cos(r^2)$



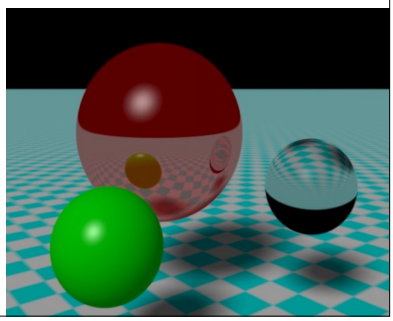


Cone/Beam Tracing

- problem: rays are infinitely thin-> point sampling
- want answer over an area
- replace ray with cone
- intersection more complicated



Amanatides 1984

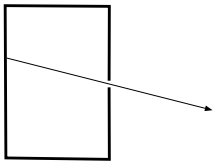


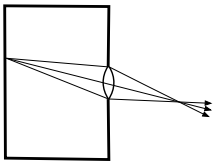
Advanced Optical Effects

- better camera models
- dull reflection
- frosted glass
- area light sources
- motion blur
- forward ray tracing

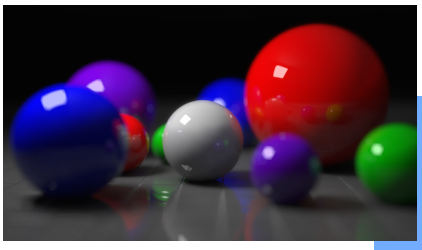
Better Camera Models

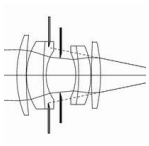
- pinhole camera model vs camera with lens
- multiple rays aimed at different parts of lens
- allows for focus, depth-of-field



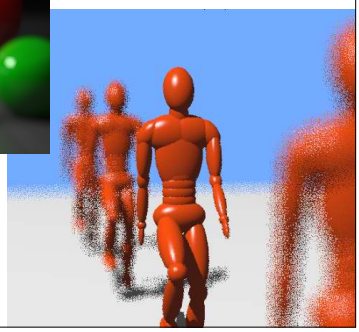


Focus/Depth-of-field



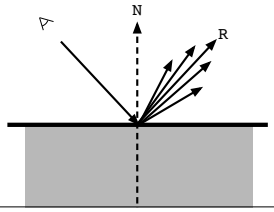


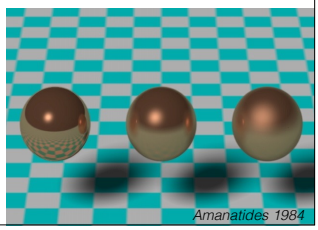
Cook 1984



Dull Reflection

- most objects not perfect reflectors
- light from off-axis direction can reach the eye
- requires multiple reflection rays
- ambient light?

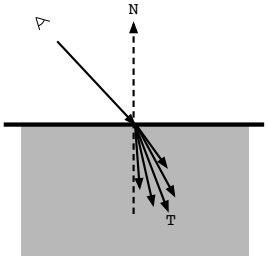


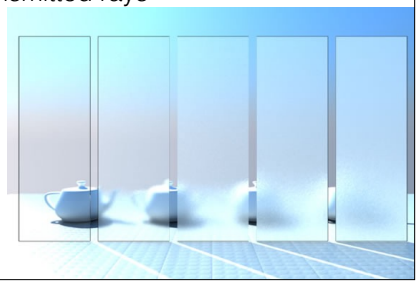


Amanatides 1984

Frosted-Glass

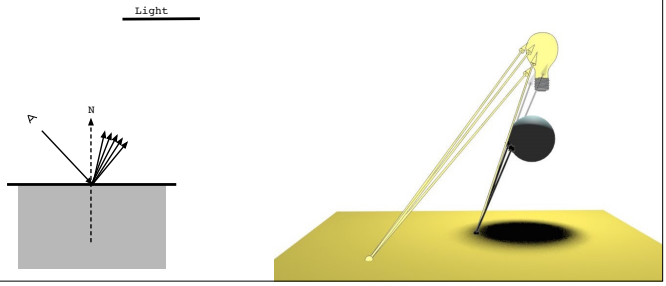
- surface of transparent object not always flat
- light from off-axis directions can reach eye
- requires multiple transmitted rays





Area Light Sources

- shoot multiple shadow probes towards different locations on light source
- fraction blocked indicate extent of shadow



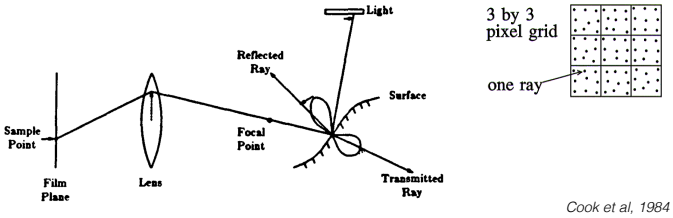
Motion Blur

- real cameras open shutter for finite amount of time (typically 15-30 ms)
- result: smear on film/image plane
- if not present, jerky, “disco ball” effect
- sample model at multiple times
  - either render multiple frames at different times and average
  - or rays sent at different times

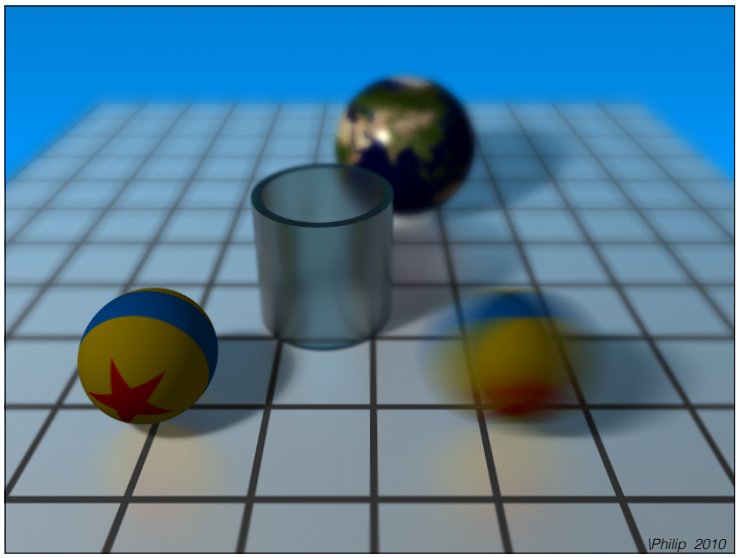
Cook 1984

Distributed Ray Tracing

- all advanced optical effects require multiple rays
- multiple rays per pixel: 8 … 64
- each ray can sample all effects independently

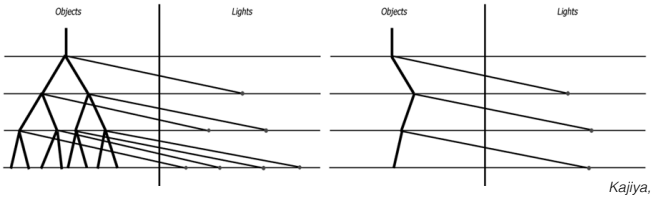


Cook et al, 1984



Path Tracing

- primary rays contribute the most
- secondary rays less important
- secondary rays: choose only one of reflected/ transmitted ray (probabilistically)
- shoot many more rays



Kajiya, 1986

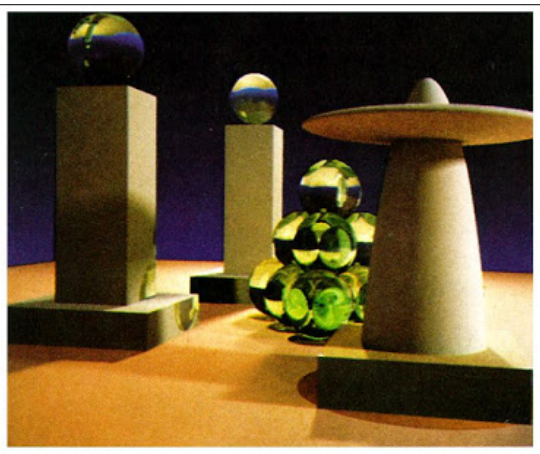
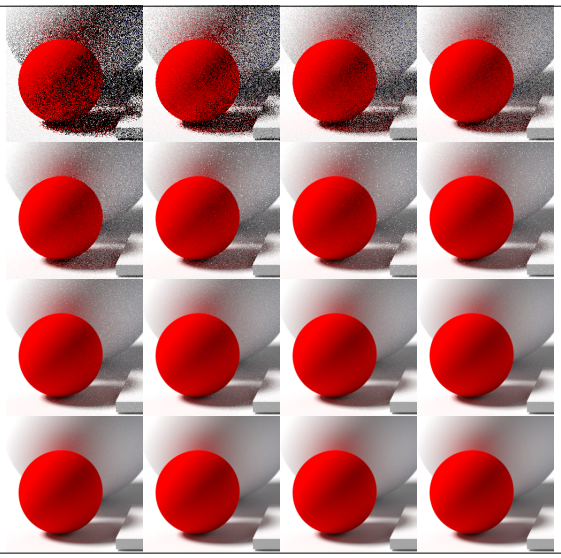


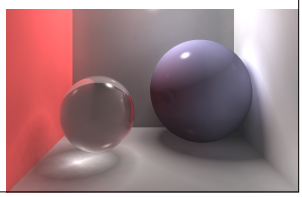
Figure 6. A sample image. All objects are neutral grey. Color on the objects is due to caustics from the green glass balls and color bleeding from the base polygon.



Wikipedia

Forward Ray Tracing

- first pass: shoot rays (“photons”) from light source
- collect photons on surfaces (store in texture maps, k-d trees)
- photons are stored only if they have been reflected or refracted (only store indirect lighting)
- second pass: regular ray tracing + photons for indirect lighting
- caustics



Lagegren 2009