Distribution Ray Tracing

## Reading

Required:

- ◆ Shirley, section 10.11

Further reading:

- ◆ Watt, sections 10.4-10.5
- ◆ A. Glassner. An Introduction to Ray Tracing. Academic Press, 1989. [In the lab.]
- ◆ Robert L. Cook, Thomas Porter, Loren Carpenter. "Distributed Ray Tracing." Computer Graphics (Proceedings of SIGGRAPH 84). *18 (3)*. pp. 137-145. 1984.
- ◆ James T. Kajiya. "The Rendering Equation." Computer Graphics (Proceedings of SIGGRAPH 86). *20 (4)*. pp. 143-150. 1986.

Gloss and translucency

The mirror-like form of reflection, when used to approximate glossy surfaces, introduces a kind of aliasing, because we are under-sampling reflection (and refraction).
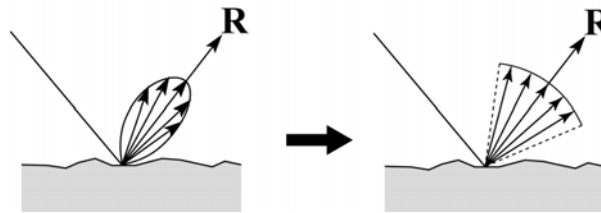
For example:
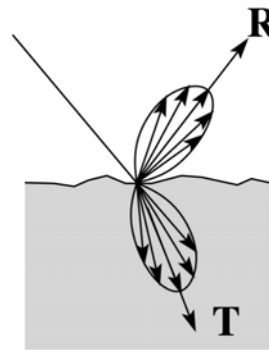
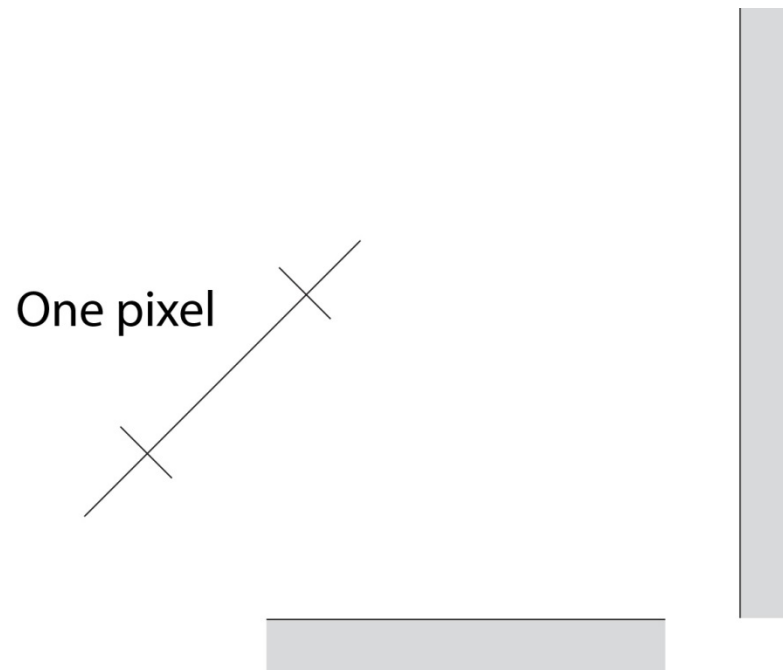Distributing rays over reflection directions gives:

Simulating glossy reflection

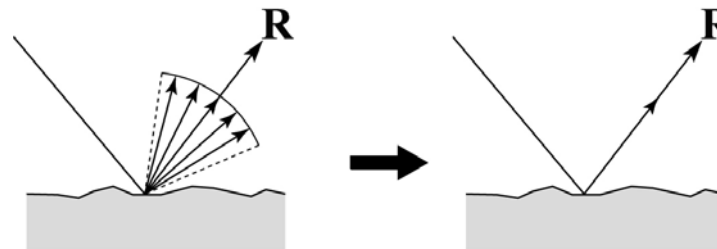Let's return to the glossy reflection model, and modify it – for purposes of illustration – as follows:

We can visualize the span of rays we want to integrate over, within a pixel:
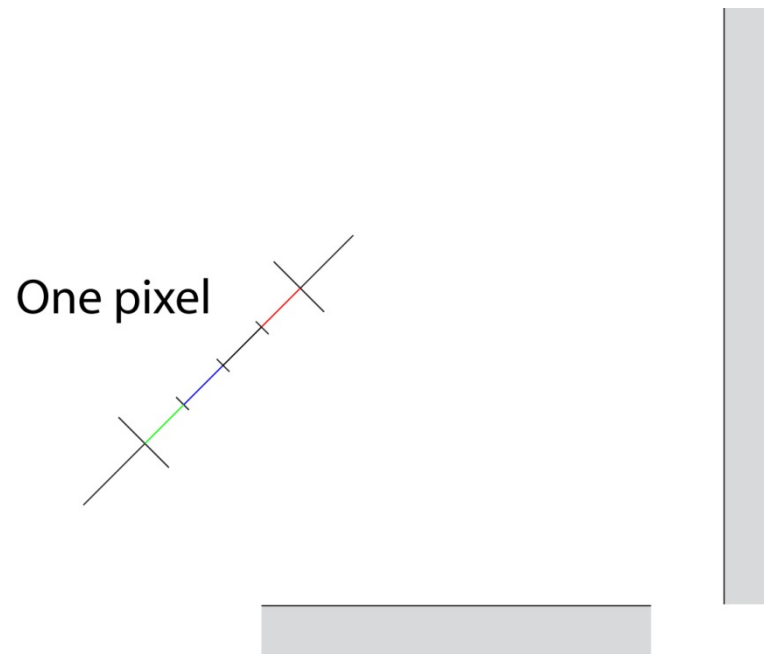
One pixel

Whitted ray tracing

Returning to the reflection example, Whitted ray tracing replaces the glossy reflection with mirror reflection:

Thus, we render with anti-aliasing as follows:

One pixel

Distribution ray tracing

We can model a glossy surface by choosing the reflection direction to be randomly perturbed away from the ideal reflection direction.

To ensure good (well-distributed) perturbations, we decompose reflection directions into bins:
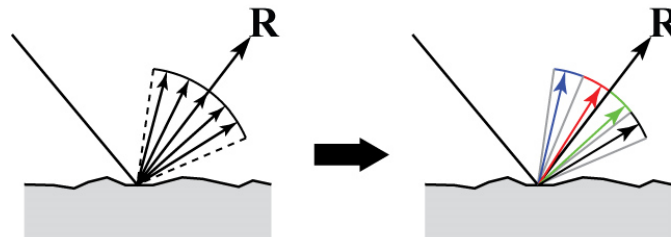
We can also perturb the sub-pixel viewing ray directions to get:

One pixel
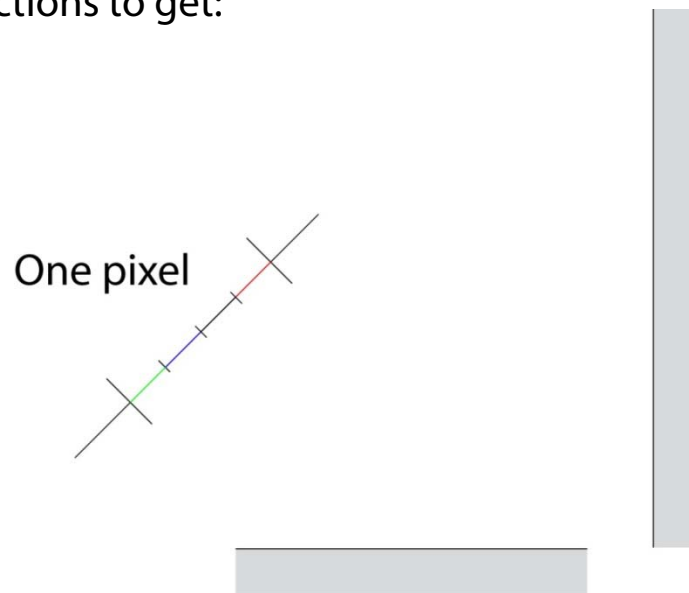
Distribution ray tracing

These ideas can be combined to give a particular method called **distribution ray tracing** [Cook84]:

- ◆ uses non-uniform (jittered) samples.
- ◆ replaces aliasing artifacts with noise.
- ◆ provides additional effects by distributing rays to sample:
  - Reflections and refractions
 - Light source area
  - Camera lens area
  - Time

In the next few slides, you will see illustration of these effects. In each case, **they can be simulated efficiently** with distribution ray tracing.

[This approach was originally called "distributed ray tracing," but we will call it distribution ray tracing (as in probability distributions) so as not to confuse it with a parallel computing approach.]
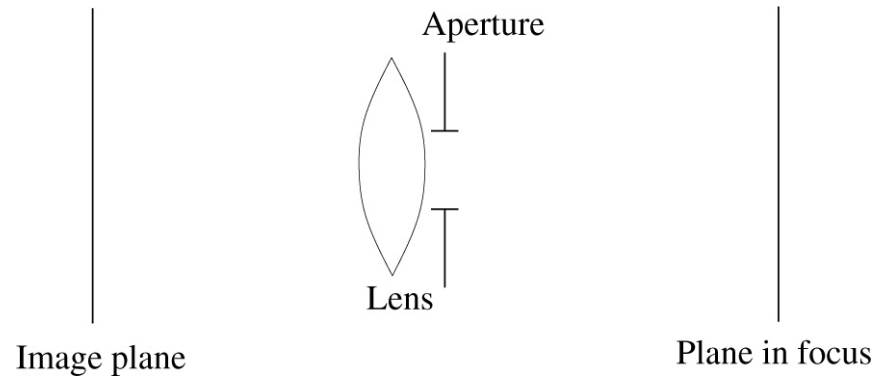
Soft shadows
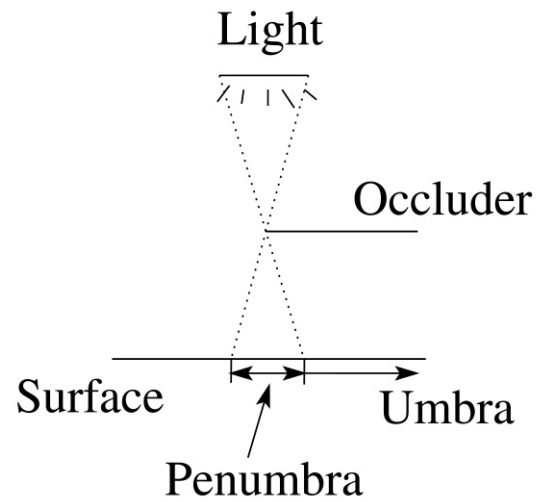
Distributing rays over light source area gives:
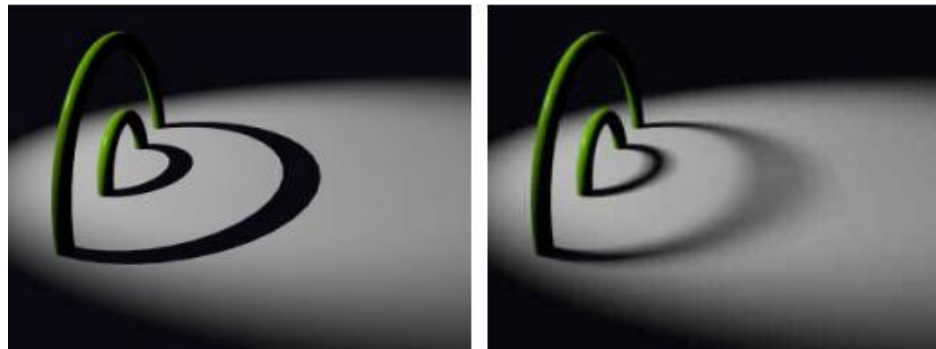
Depth of field

To simulate a camera, we can model the refraction of light through a lens. This will give us a "depth of field" effect: objects close to the in-focus plane are sharp, and the rest is blurry.

DRT to simulate _____

Distributing rays over time gives:

Summary

What to take home from this lecture:

1. The limitations of Whitted ray tracing.
2. The main idea behind distribution ray tracing and what effects it can simulate.