Lecture 12:
Ray Tracing Basics

Reading

Required:

- Hearn & Baker, 14.6

Optional:

- Glassner, chapter 1
- Foley *et al.*, 16.12

Ray Tracing

- A term from optics
- A “physical” simulation of the particle theory of light

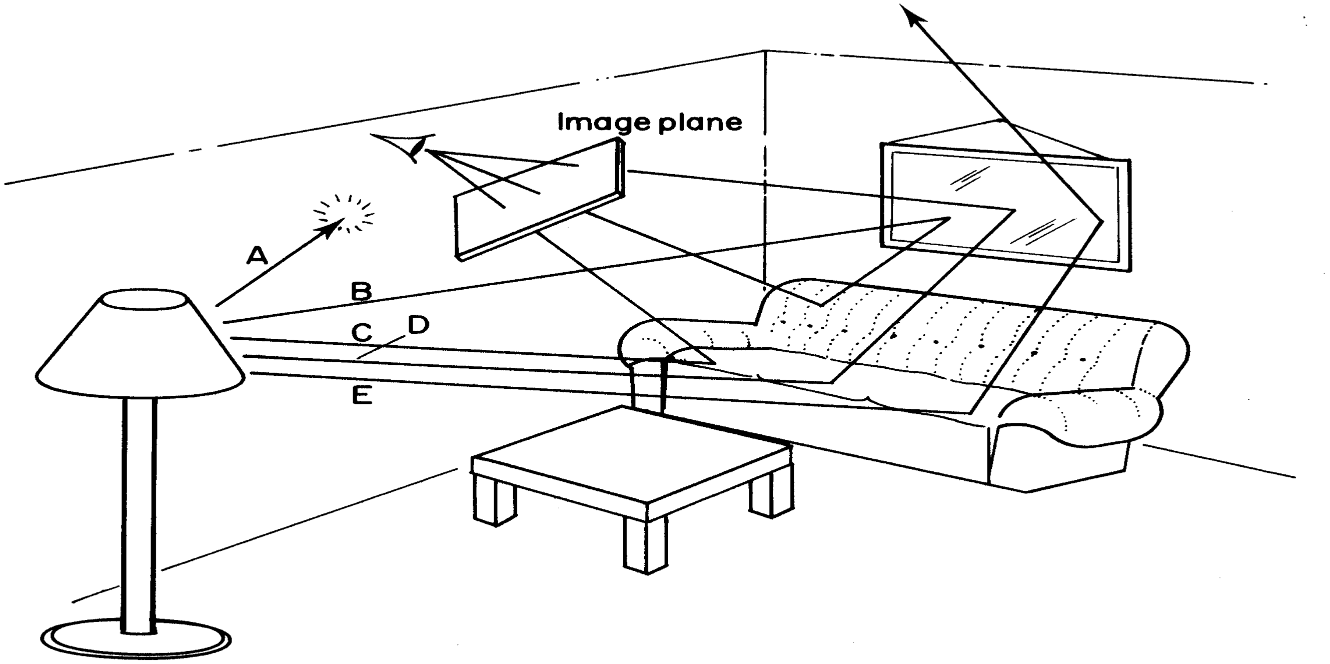
- In the 1960s, ray tracing seemed like a great idea, but nobody could do it well enough to beat cheaper image synthesis methods.
- These days, we can follow the simulation deeply enough to get great results!
- But there are some visual phenomena that ray tracing **cannot do**.

Why Ray Tracing?

- So far, we can do **ray casting**: for each pixel in the projection plane, find the object visible at that pixel and apply your favorite shading model.
- What does this model miss?

Forward Ray Tracing

- Rays emanate from light sources and bounce around in the scene.
- Rays that pass through the projection plane and enter the eye contribute to the final image.



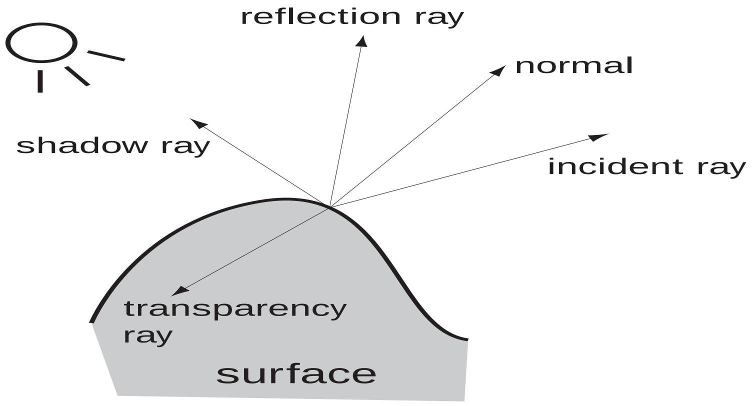
- What's wrong with this method?

Backward Ray Tracing

- Rather than propagating rays indiscriminately from light sources, we’d like to ask “which rays will definitely contribute to the final image?”
- We can get a good approximation of the answer by firing rays from the eye, through the projection plane and into the scene
  - These are the paths that light must have followed to affect the image

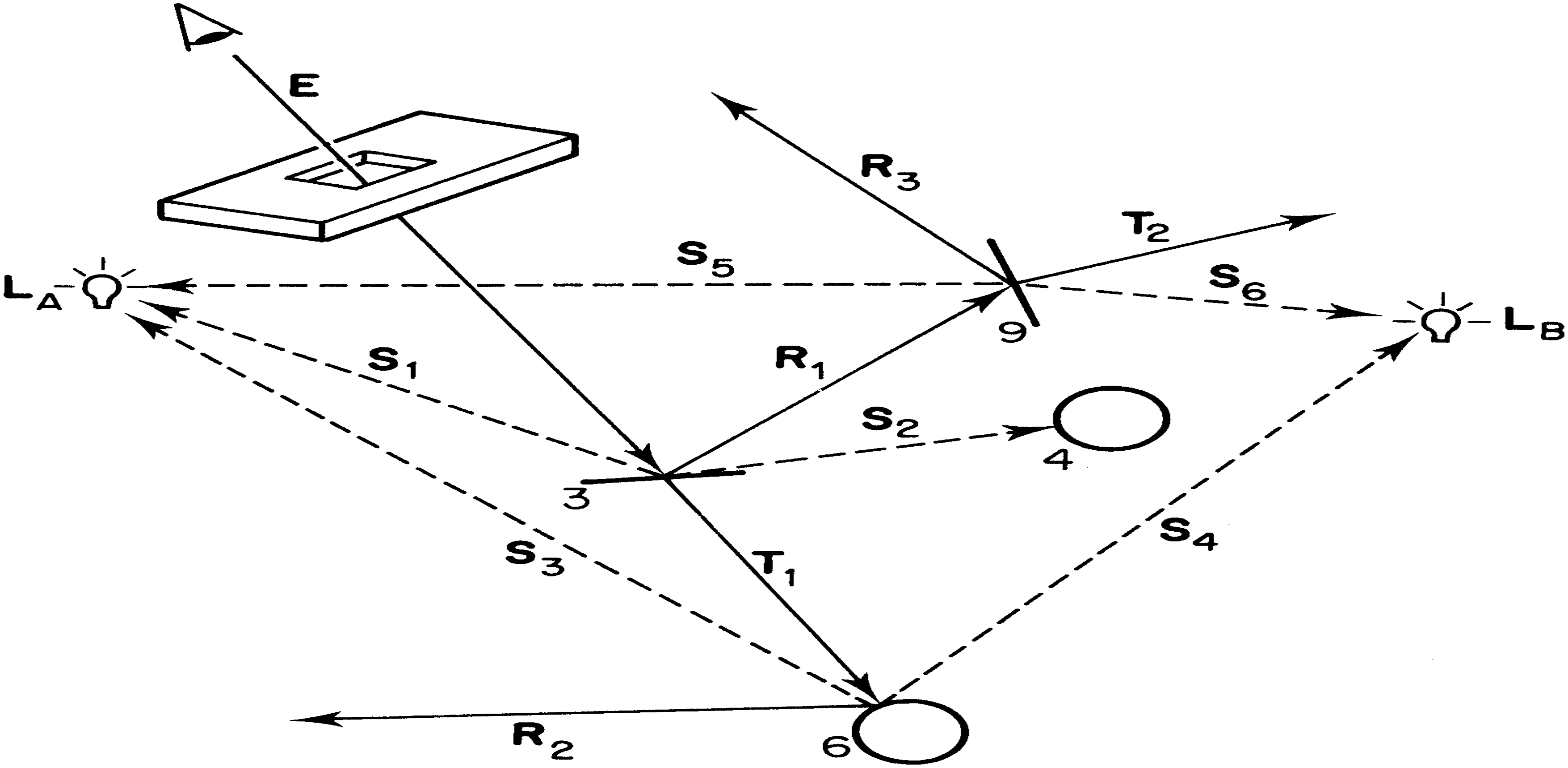
Kinds of Rays

- A ray that leaves the eye and travels out to the scene is called a **primary ray**.
- When a ray hits an object, we spawn three new (backward) rays to collect light that must contribute to the incoming primary ray:
  - **Shadow rays** to light sources, used to attenuate incoming light when applying the shading model
  - **Reflection rays**, which model light bouncing off of other surfaces before hitting this surface
  - **Transparency rays**, which model light refracting through the surface before leaving along the primary ray



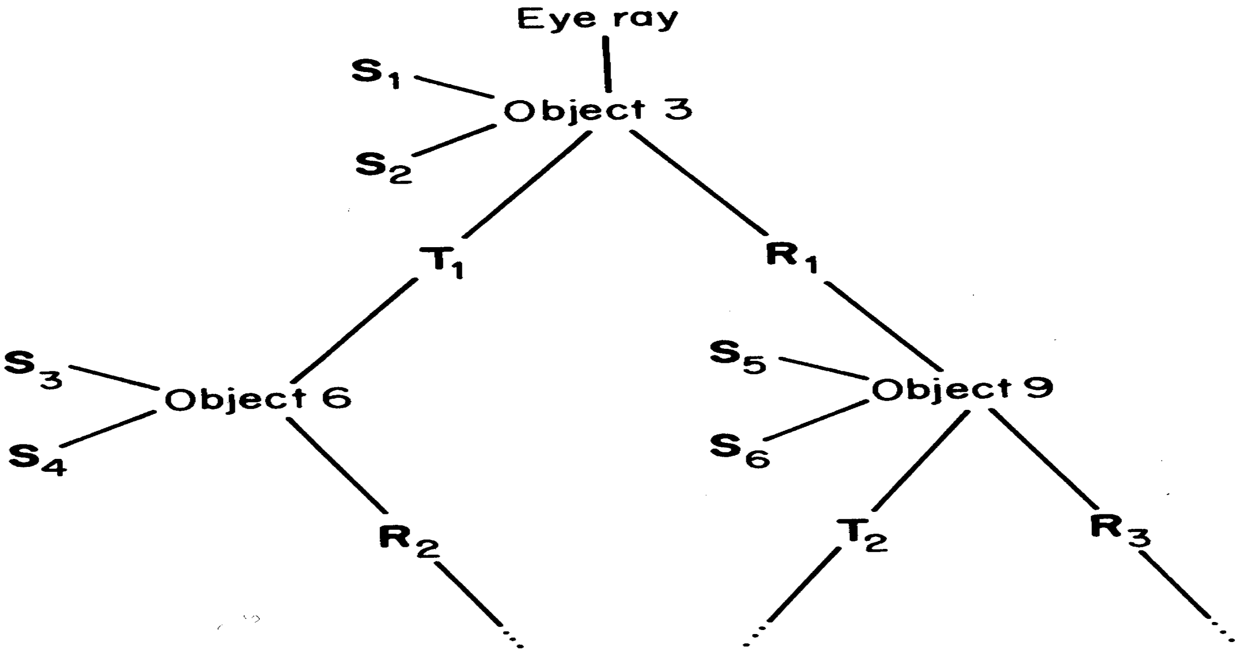
- Shadow rays stop at light sources, but reflection and transparency rays behave just like primary rays!

Example of Ray Tracing



The Ray Tree

- A primary ray hits a surface and spawns reflection and transparency rays. Those rays may hit surfaces and spawn their own rays, etc.
- We can represent this process schematically using a **ray tree**:



- What is a ray tree good for?

Controlling Tree Depth

- Ideally, we’d spawn child rays at every object intersection forever, getting a “perfect” colour for the primary ray.
- In practice, we need heuristics for bounding the depth of the tree (i.e., recursion depth)
- ?

Parts of a Ray Tracer

- What major components make up the core of a ray tracer?

Summary

- Understanding of basic ray tracing concepts
- Forward vs. backward tracing
- Classification of rays
- The ray tree
- Terminating recursion
- Parts of a ray tracer