How does the eye see?

Plato (428-347 B.C.)

- the eye is a lantern
- seeing is a meeting of inner and outer light

Aristotle (384-322 B.C.)

- the eye is a darkened chamber awaiting light
- first described the *camera obscura*

Alhazen (965-1039 A.D.)

- the eye refracts the visible hemisphere into the optic path
- each point in eye sees one ray in scene

Leonardo DaVinci (1452-1519)

- **explored schemes to avoid inverted image**
- **recognized importance of paraxial rays**

Kepler (1571-1630)

- **theory of the retinal image**
- **laws of geometric optics**

Descartes (1596-1650)

- **verified Kepler by looking through an ox's eye**

Modern views of light

Geometrical optics

- **Newton** — **corpuscles emitted from shining objects**
- **Gauss** — **ray tracing through lenses**

Wave optics

- **Descartes** — **motion in a *plenum***
- **Euler** — **vibrations in *ether***
- **Faraday** — **vibrations in a field**
- **Maxwell** — **an electromagnetic disturbance**

Quantum physics

- **Einstein** — **light quanta (*photons*)**

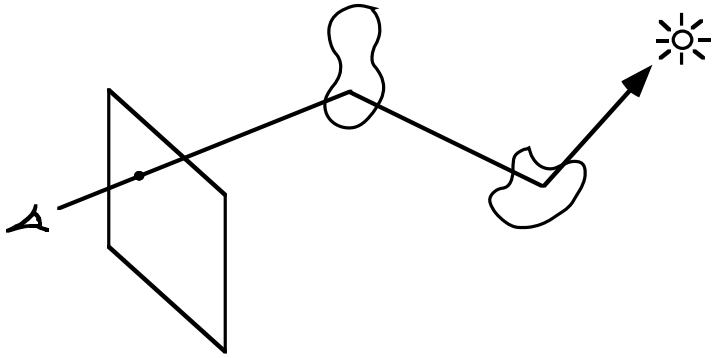
Premises of ray tracing

1. **Light rays travel in straight lines**
2. **Light rays do not interfere with each other if they cross**
3. **Light rays travel from the light sources to the eye, but the physics is invariant under path reversal (*reciprocity*)**

Where does a ray begin?

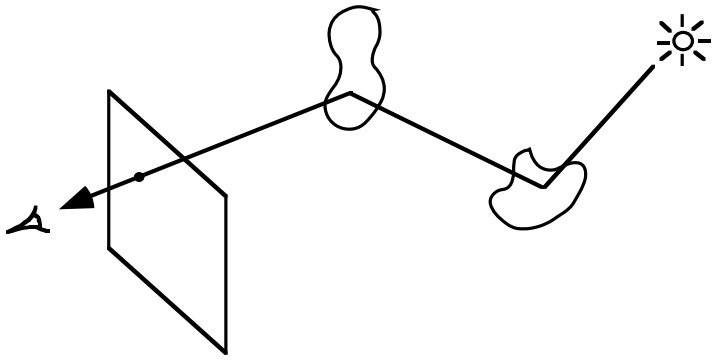
At the eye

- eye ray tracing



At the light

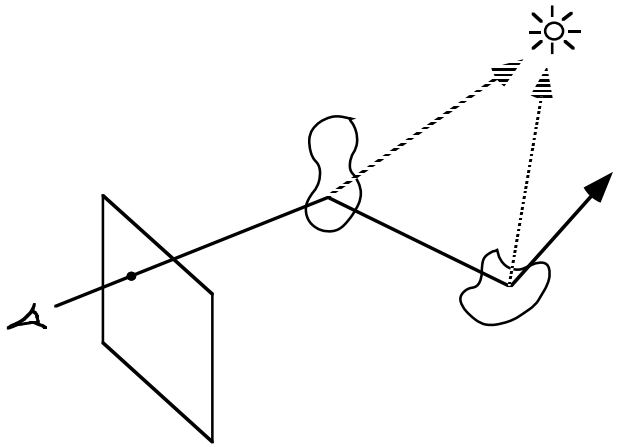
- light ray tracing
- a.k.a. photon tracing



Hybrid solutions

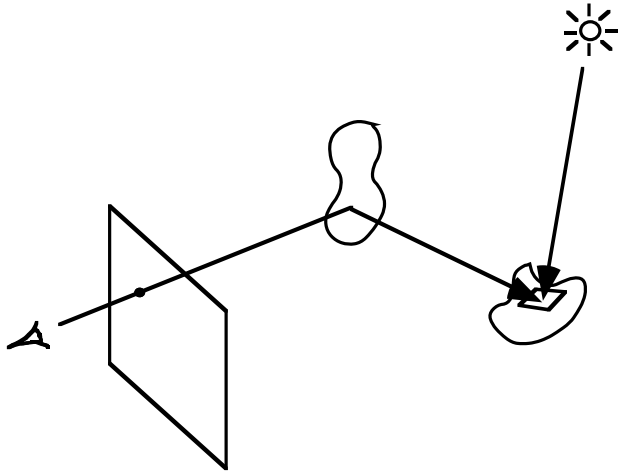
Whitted (1980)

- **eye ray tracing**
  +
  rays to light



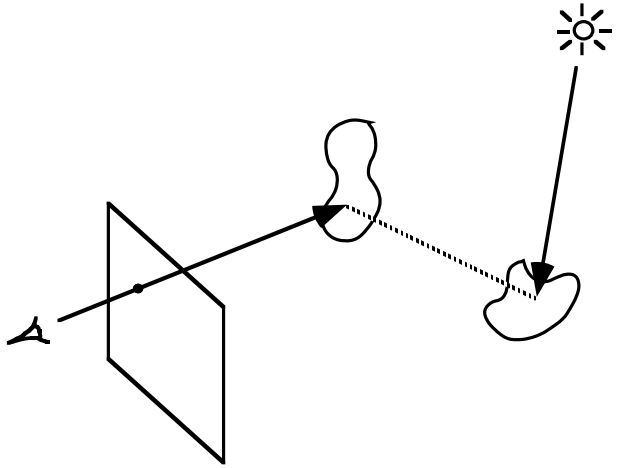
Heckbert (1990)

- **eye ray tracing**
  +
  light ray tracing
  +
  storage on surface



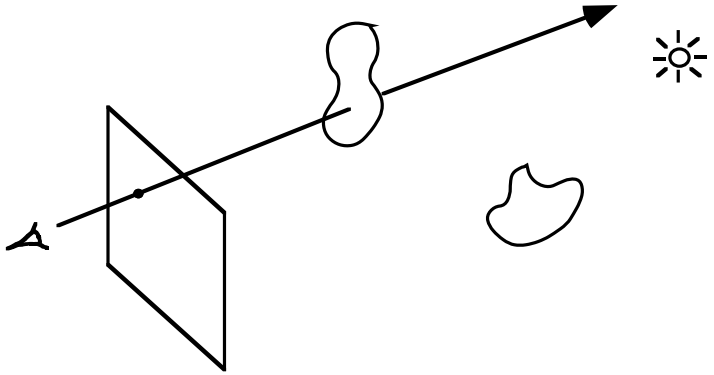
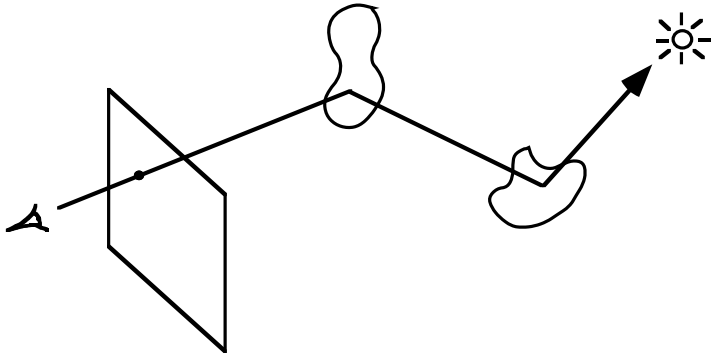
Veach (1995)

- **eye ray tracing**
  +
  light ray tracing
  +
  connecting lines



Casting versus tracing

1st path = ray casting



recursive = ray tracing