Basic idea
Intersection approaches

- Plug parametric ray into implicit shape
- Plug parametric shape into implicit ray
- Solve implicit ray = implicit shape
Making it easier

- Transform to canonical ray
  - \((0,0,0)\rightarrow(0,0,1)\)

- Transform to canonical object
  - Ellipsoid to unit sphere at \((0,0,0)\)

- Compute in stages
  - Polygon plane, then polygon edges

- Numerical iteration
How many intersections?

- Pixels
  - \(~10^3\) to \(~10^7\)
- Rays per Pixel
  - 1 to \(~10\)
- Primitives
  - \(~10\) to \(~10^7\)
- Every ray vs. every primitive
  - \(~10^4\) to \(~10^{15}\)
Speedups

- Faster intersections
- Fewer intersections
Fewer intersections

- Object-based
- Space-based
- Image-based
Object: bounding hierarchy

- Bounding spheres
- AABB
- OBB
- Slabs
Bounding spheres

- Very fast to intersect
- Hard to fit
- Poor fit
AABB

- Fast to intersect
- Easy to fit
- Reasonable fit
OBB

- Pretty fast to intersect
- Harder to fit
  - Eigenvectors of covariance matrix
  - Iterative minimization
- Good fit
Slabs

- Families of planes
- Fast intersection
Space: partitioning

- Slabs
- Uniform grid
- Octtree
- BSP
Image

- Coherence
  - Light buffer (avoid shadow rays)
  - Pencil tracing/cone tracing

- Image approximation
  - Truncate ray tree
  - Successive refinement
  - Contrast-driven antialiasing
Algorithmic improvements

- **Object-based**
  - Decide ray doesn’t intersect early

- **Space-based**
  - Partial order of intersection tests

- **Image-based**
  - Ray-to-ray coherence
Faster intersections

- Precompute and store with object
- Cache results from previous tests
- Stop early for reject
- Postpone expensive operations
  - Reject then normalize
- If a cheap approximate test exists, do it first
  - Sphere / box / separating axes / …
- Project to fewer dimensions
Parallel intersections

- Distribute pixels
- Distribute rays
- Distribute objects
Parallel intersections

- Load balancing
  - Scattered rays, blocks, lines, ray queues
- Culling
- Communication costs
  - Database
  - Ray requests
  - Ray results