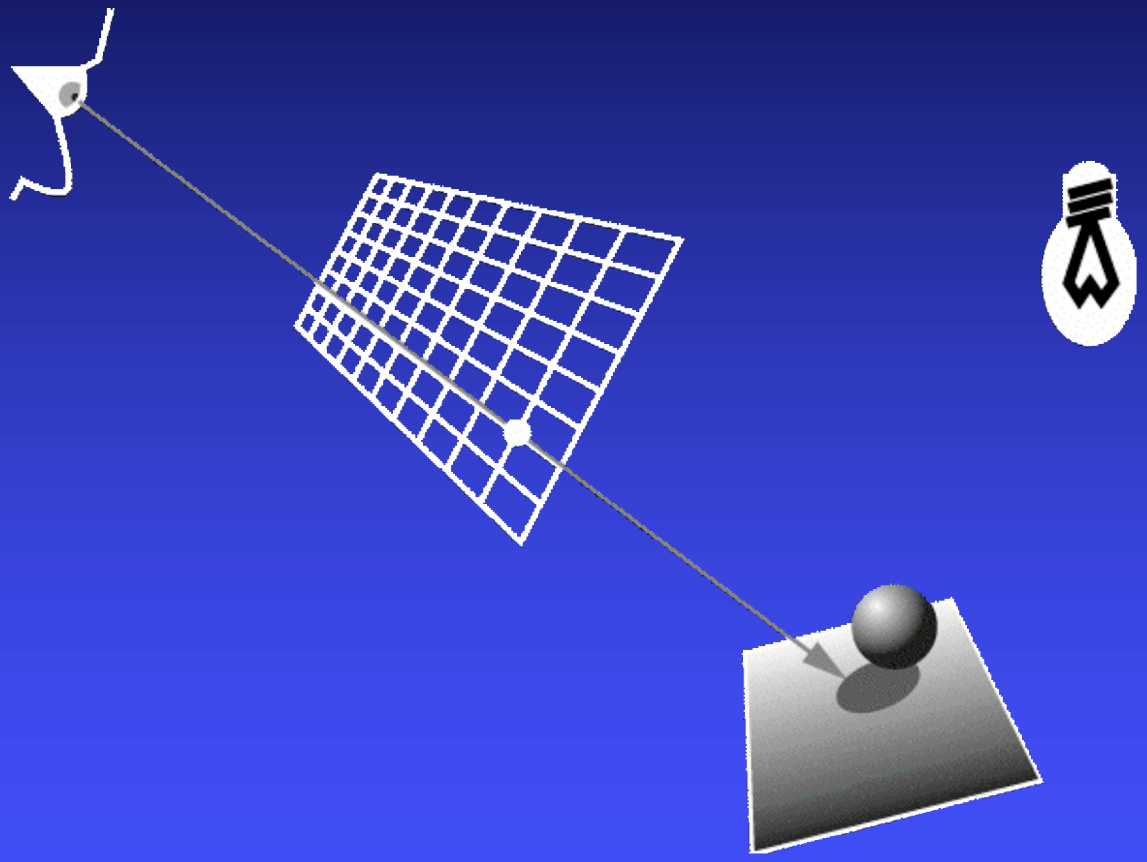
CMSC 635

Ray Tracing

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 cannonical ray
  - (0,0,0)–(0,0,1)
- Transform to cannonical 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