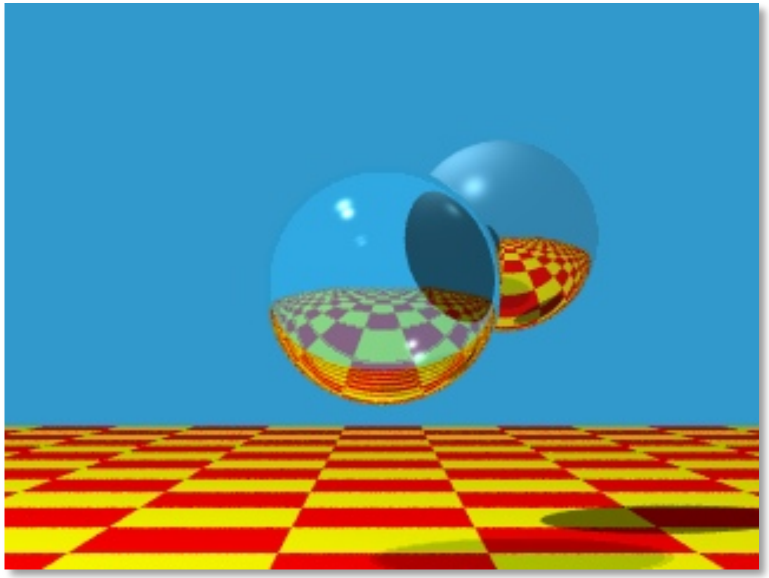
Ray-tracing

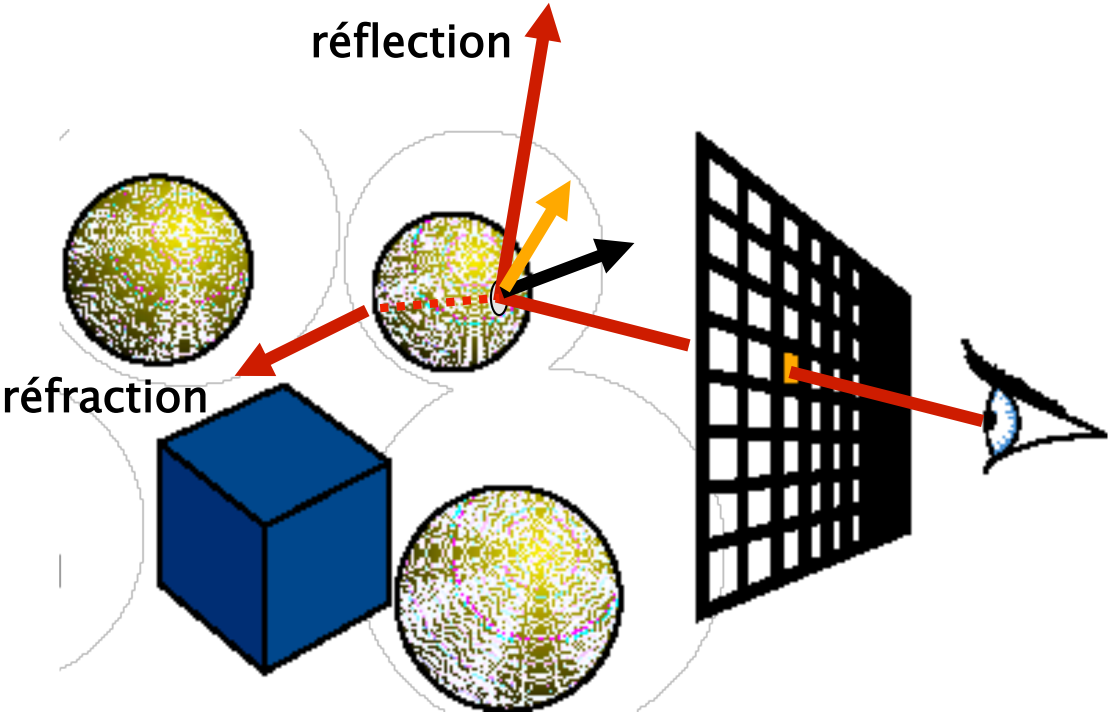
Ray-tracing

- **Ray casting, ray tracing**: rays sent from view point towards the scene.
- One ray for every pixel.
- Pixel color depends on illumination at the first surface intersected by the ray
- Using local illumination models

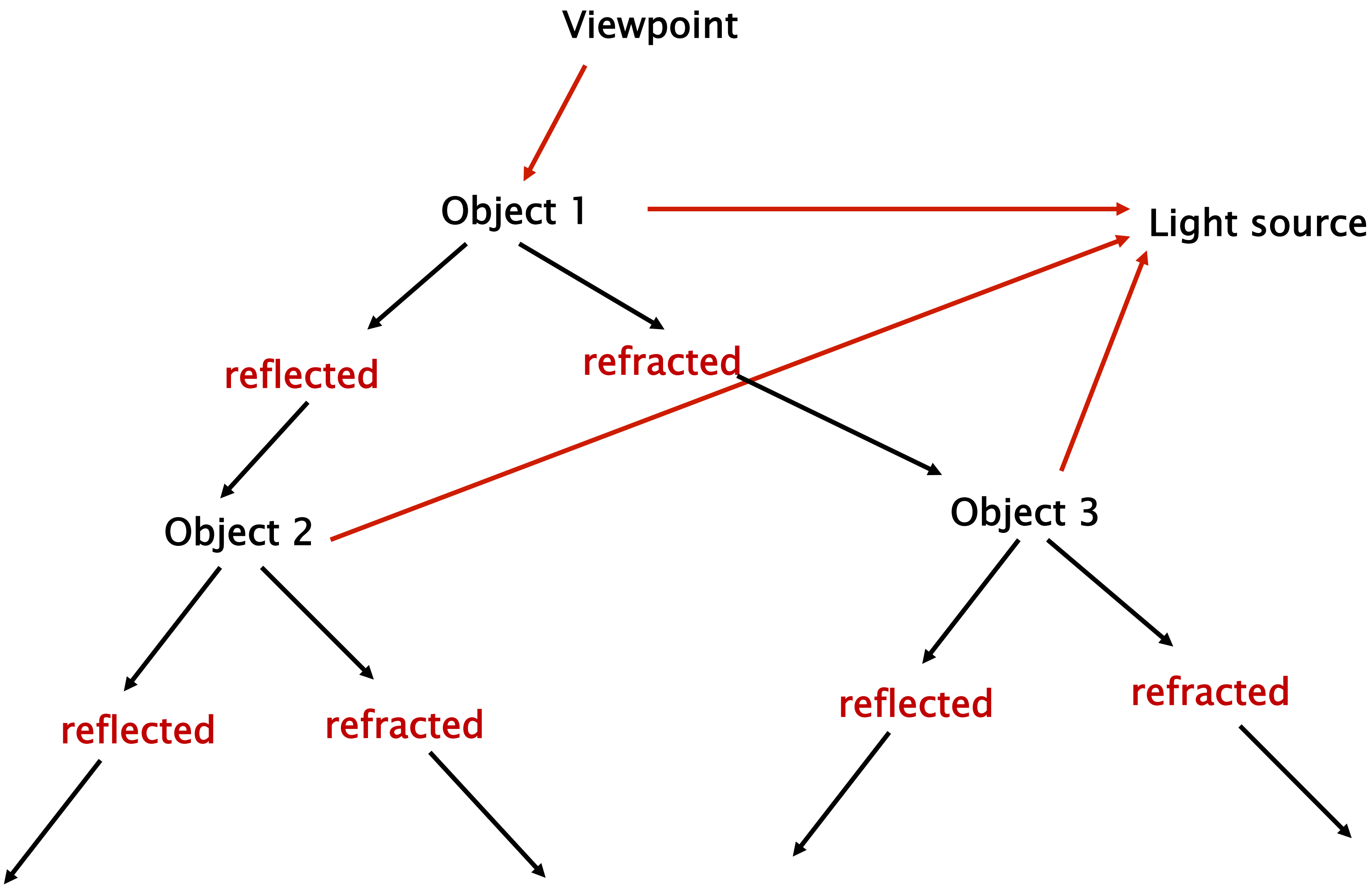
Extension

- Three new rays are generated:
  refracted ray, reflected ray, shadow ray





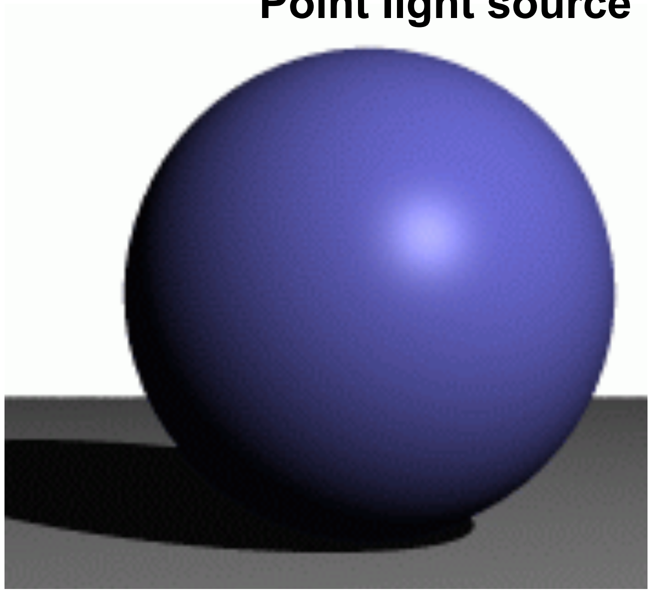
Ray-tree


Viewpoint
Object 1
Light source
reflected
refracted
Object 2
Object 3
reflected
refracted
reflected
refracted

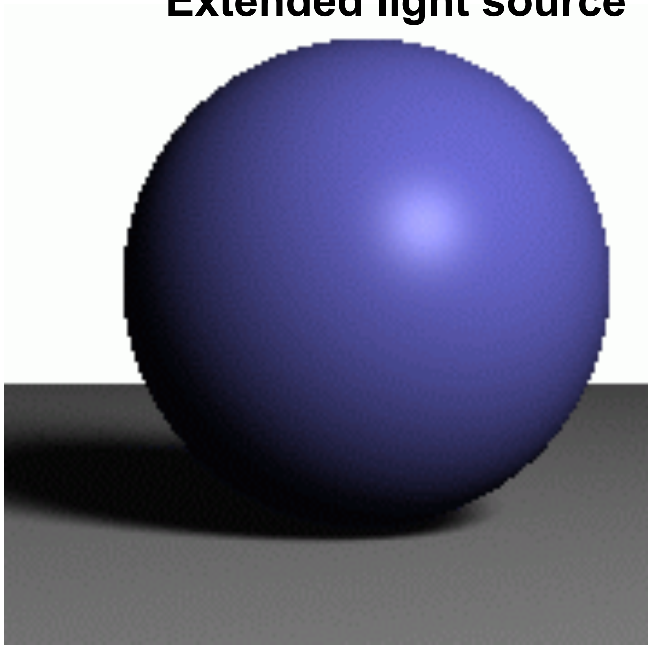
Even more rays

- Soft shadows
  - Several shadow rays for each extended light source

Point light source

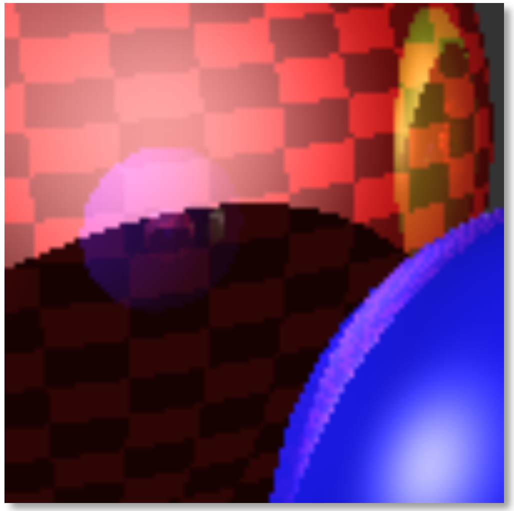


Extended light source

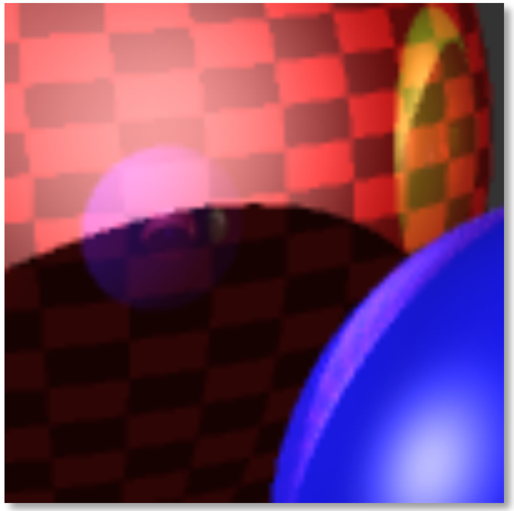


Even more rays

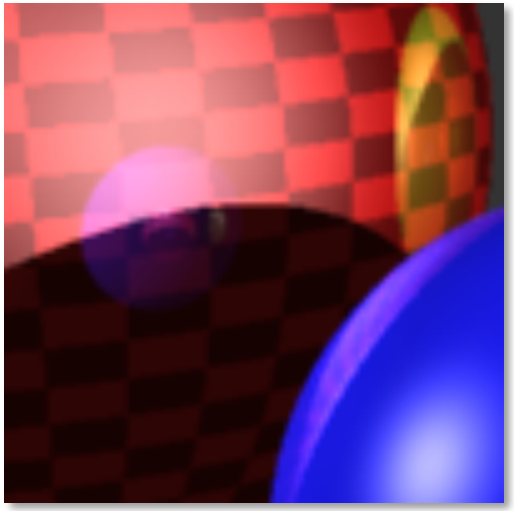
- Soft shadows
  - Several shadow rays for each extended light source
- Anti-aliasing
  - Several rays per pixel



1 rayon



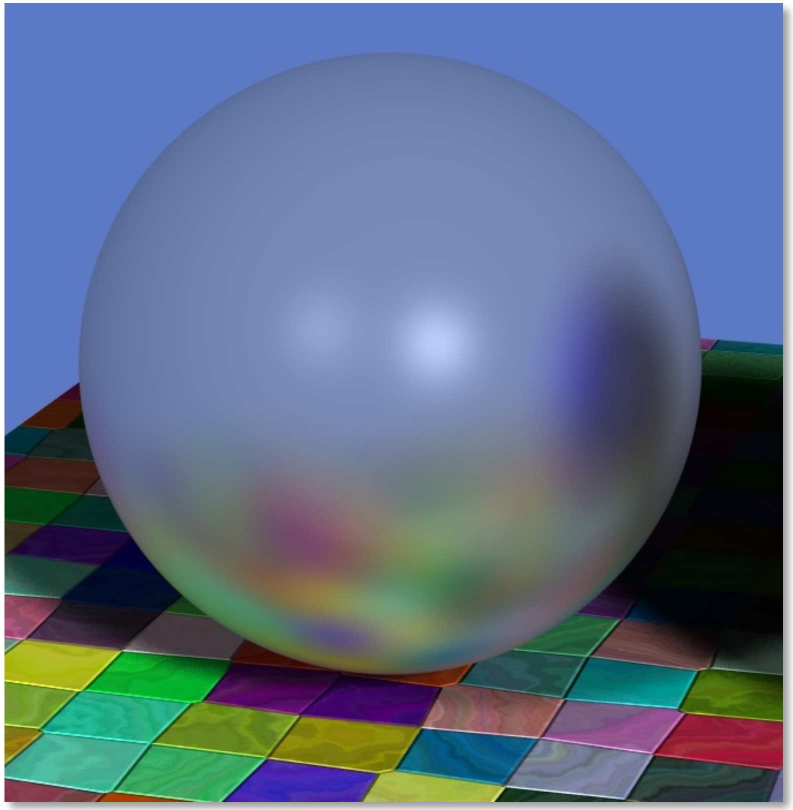
2 rayons



3 rayons

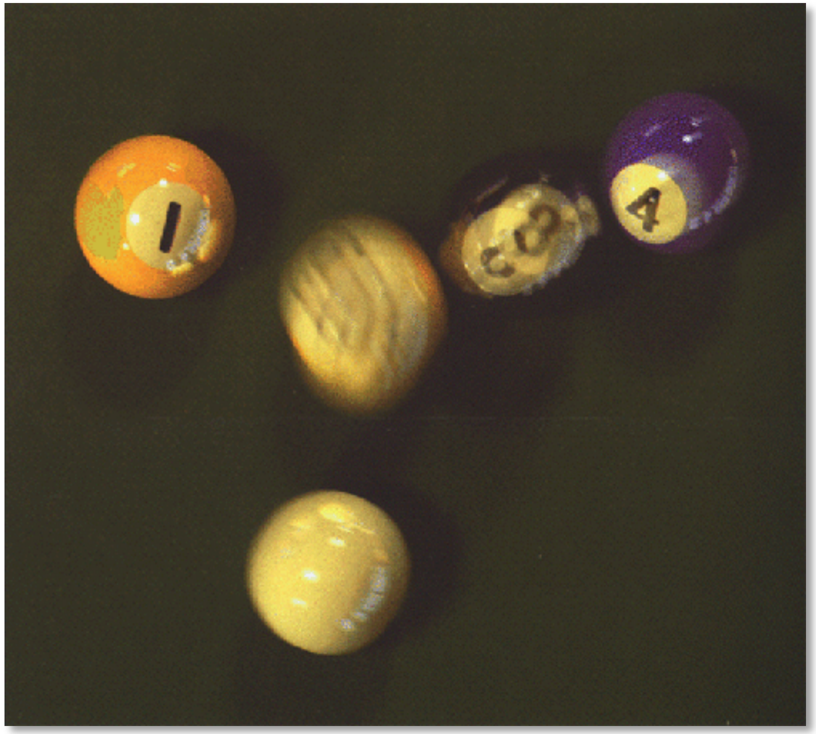
Even more rays

- Soft shadows
  - Several shadow rays for each extended light source
- Anti-aliasing
  - Several rays per pixel
- Glossy reflections
  - Several reflected rays



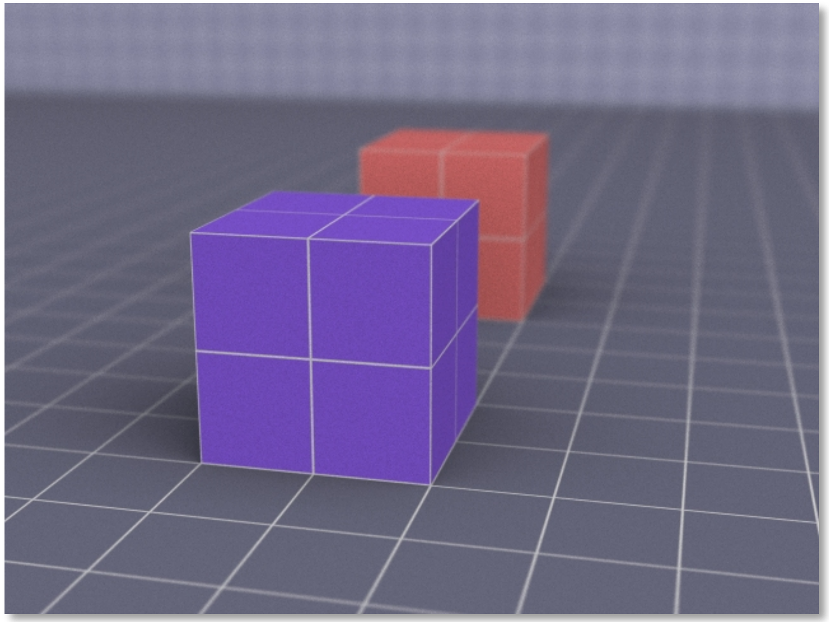
Even more rays

- Soft shadows
  - Several shadow rays for each extended light source
- Anti-aliasing
  - Several rays per pixel
- Glossy reflections
  - Several reflected rays
- Motion blur
  - Several rays through time



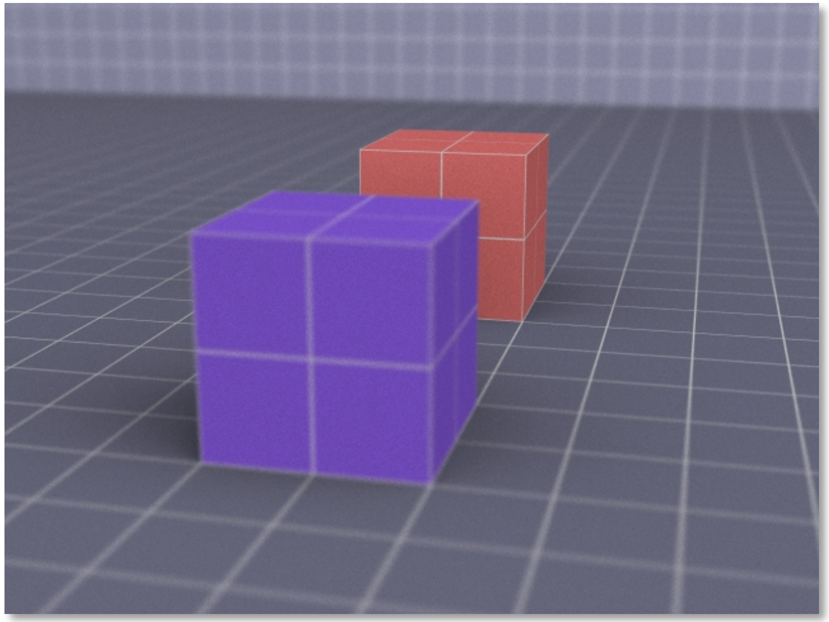
Even more rays

- Soft shadows
  - Several shadow rays for each extended light source
- Anti-aliasing
  - Several rays per pixel
- Glossy reflections
  - Several reflected rays
- Motion blur
  - Several rays through time
- Depth of field
  - Several rays per pixel through the lens



Even more rays

- Soft shadows
  - Several shadow rays for each extended light source
- Anti-aliasing
  - Several rays per pixel
- Glossy reflections
  - Several reflected rays
- Motion blur
  - Several rays through time
- Depth of field
  - Several rays per pixel through the lens



Ray-scene intersection

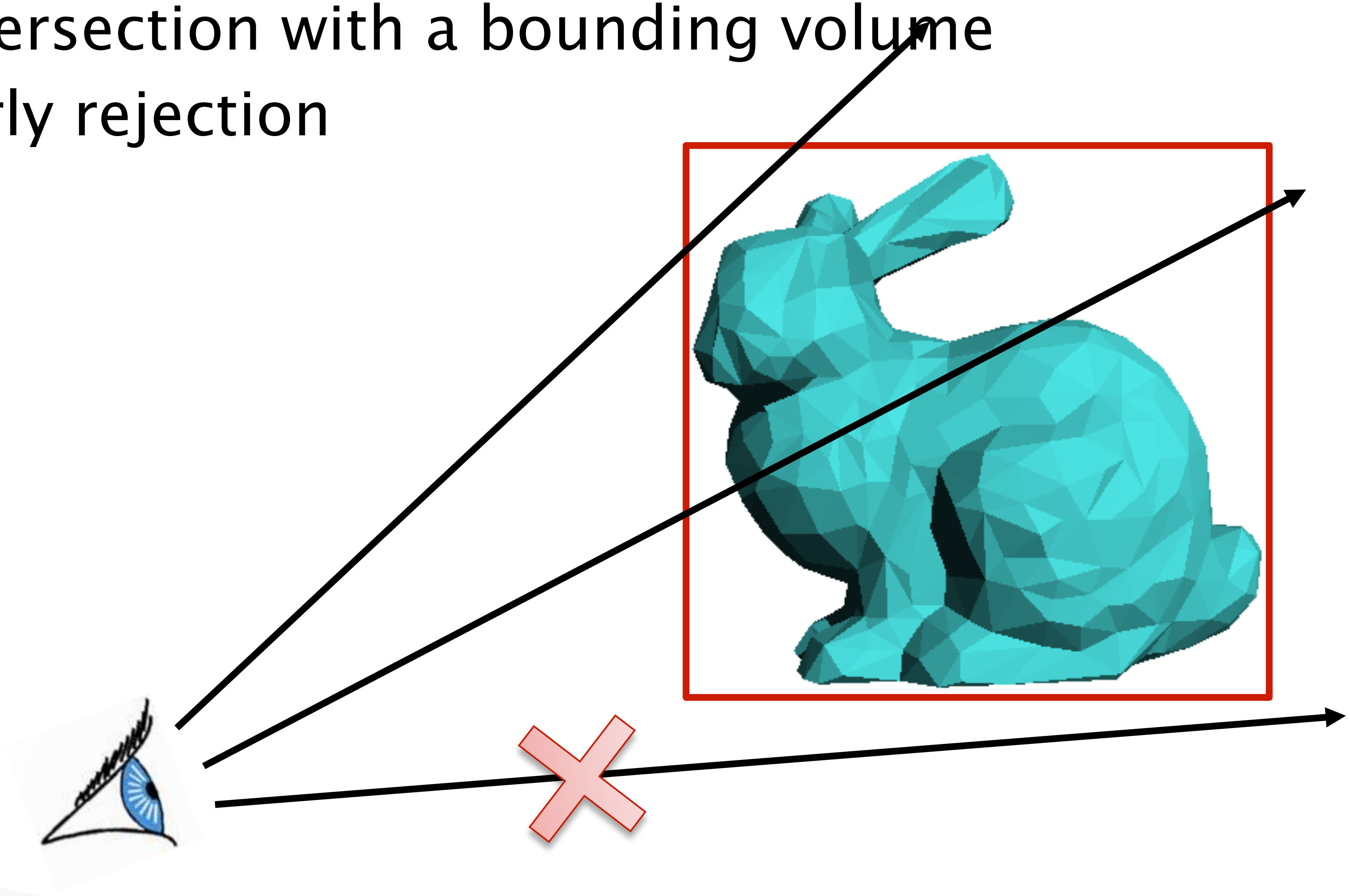
- Ray-sphere: point-line distance.
- Ray-cylinder: line-line distance.
- Ray-plane: line-plane intersection
- Ray-polygon:
  - line-plane intersection.
  - test whether intersection point is in polygon:
    - project onto xy plane, check inside 2D polygon.

Ray-scene intersection

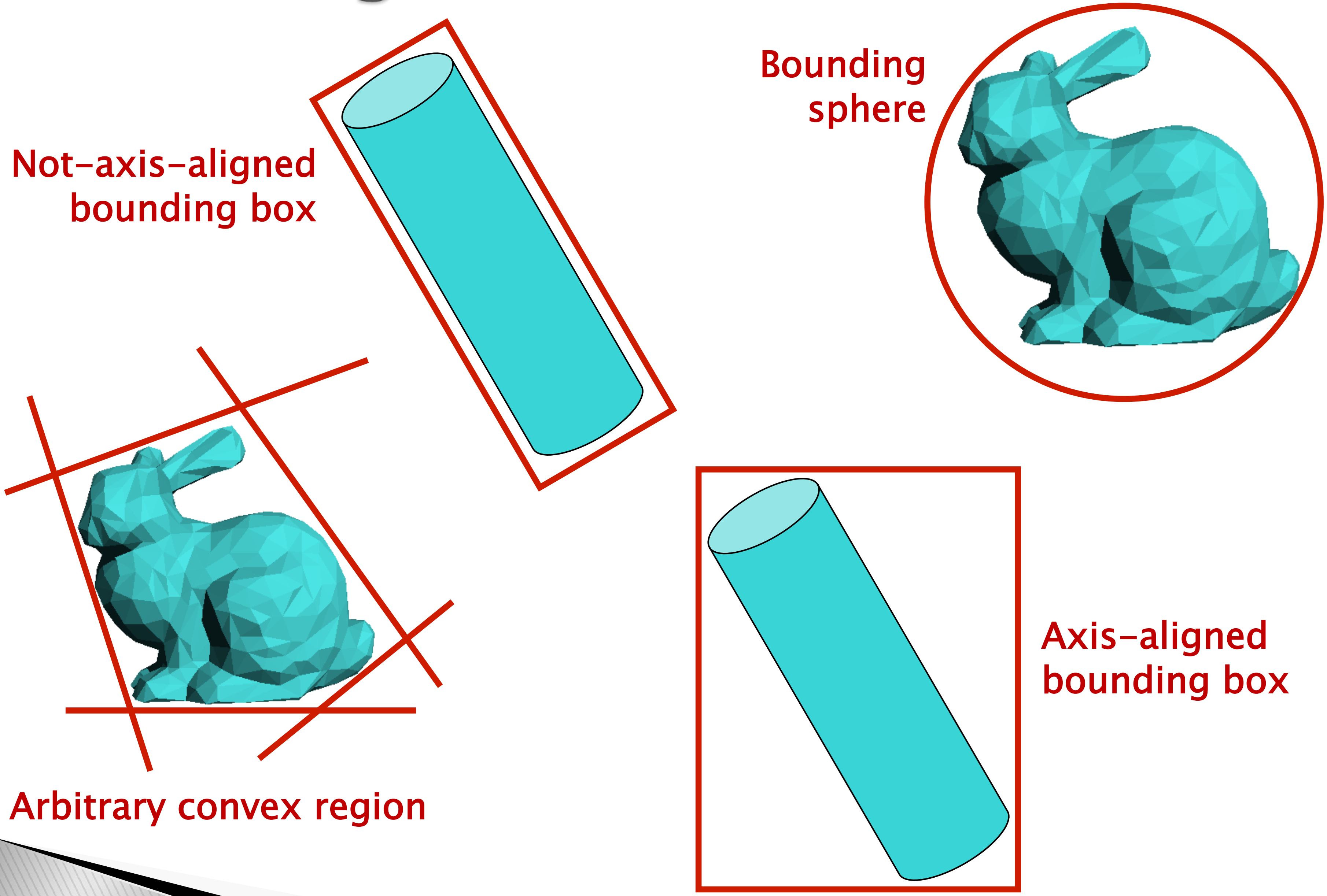
- 99 % of the time is spent doing intersections.
- Need for accelerations:
  - bounding volumes,
  - uniform grids (voxels),
  - octrees,
  - BSP-trees,
  - problem specific accelerations;

Bounding volumes

- Intersection with a bounding volume
- Early rejection



Bounding volumes



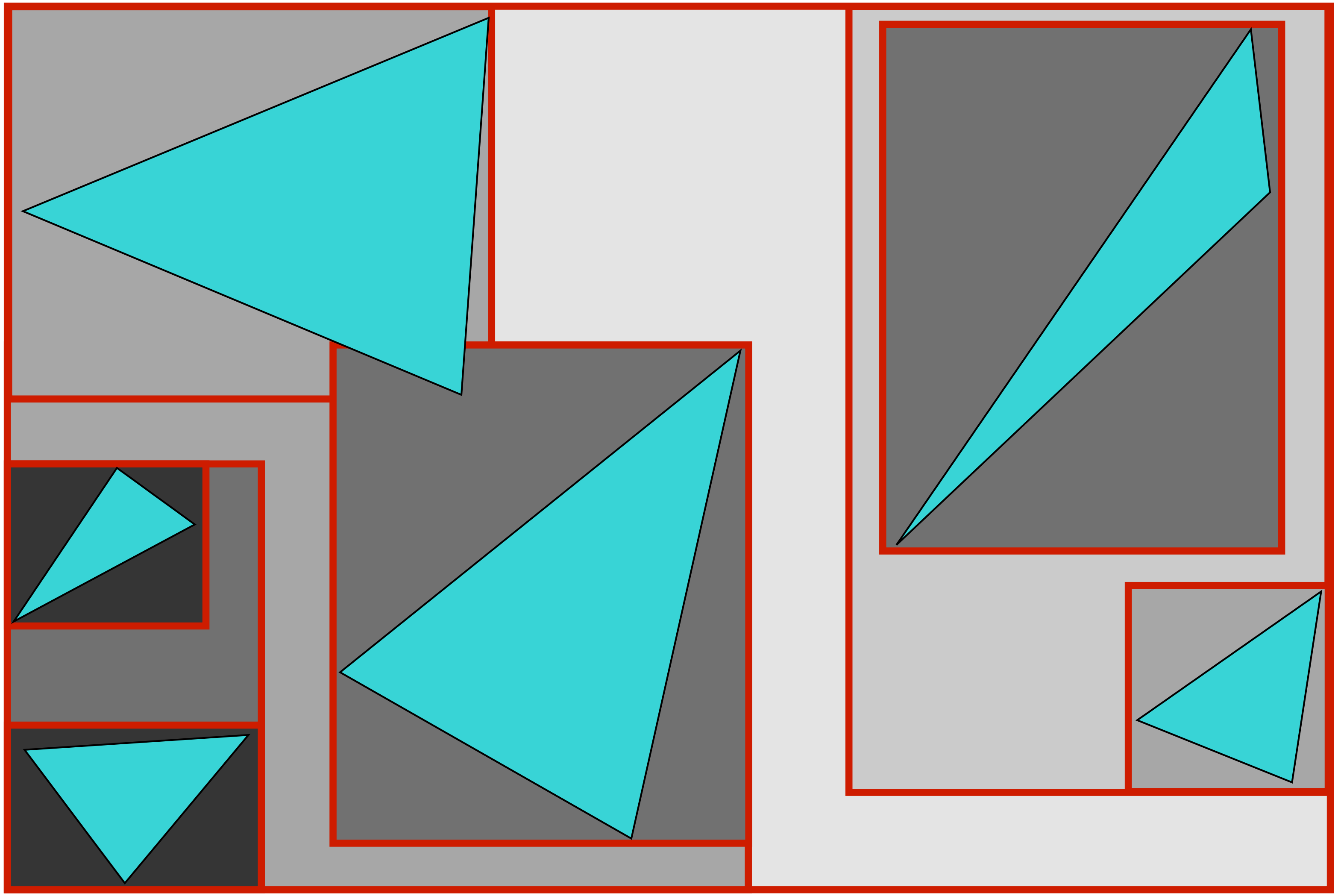
Bounding sphere

Not-axis-aligned bounding box

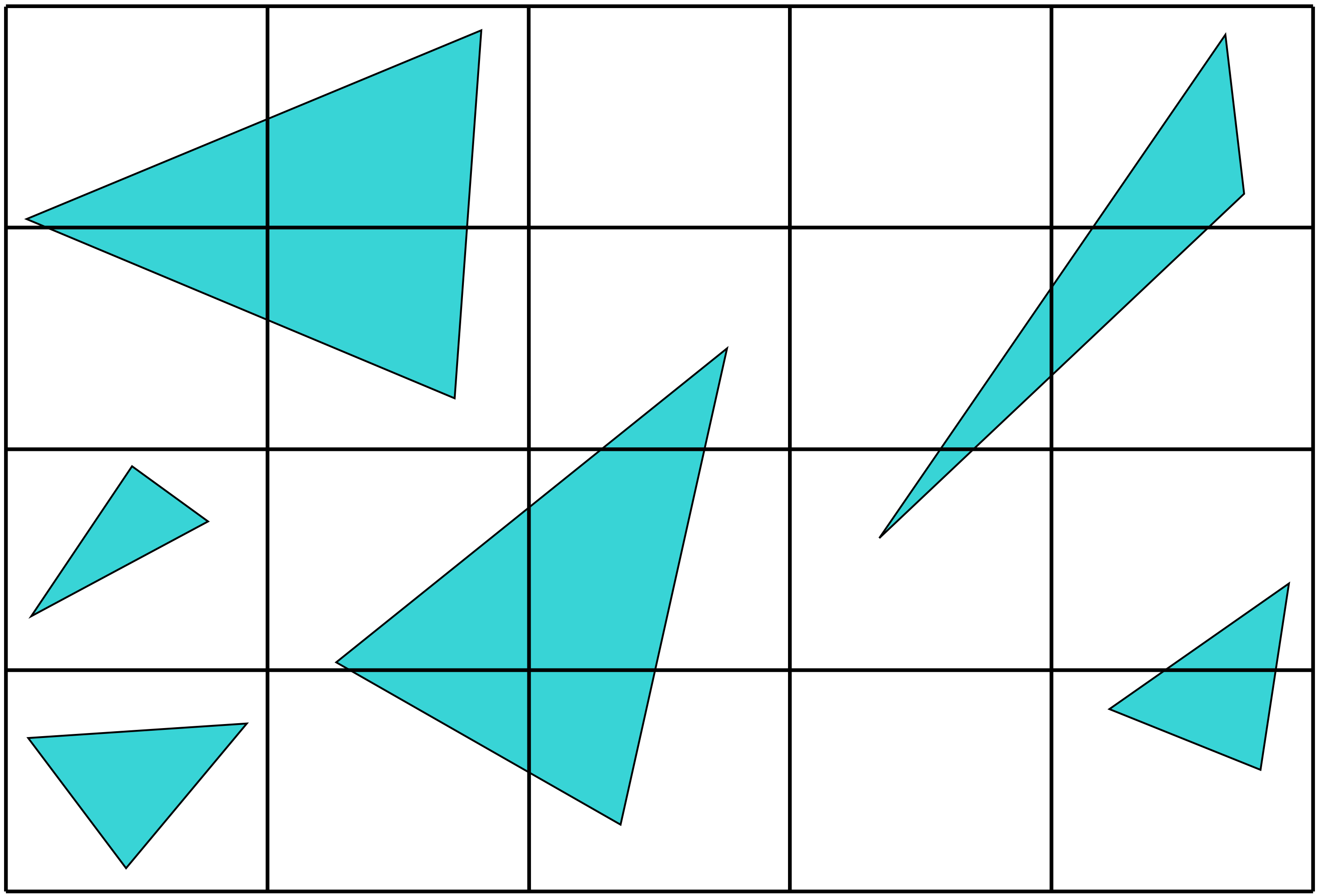
Arbitrary convex region

Axis-aligned bounding box

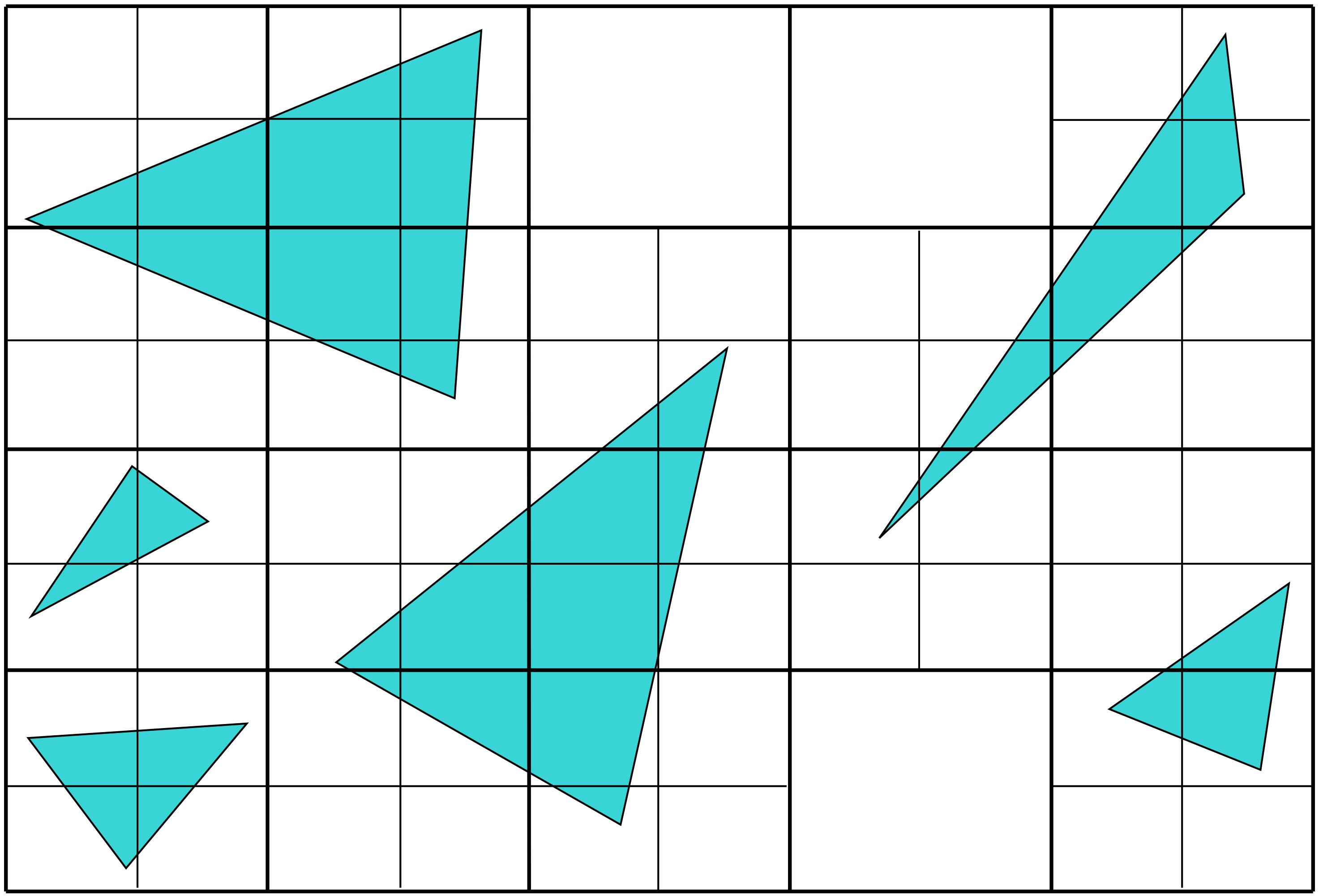
BVH: Bounding Volume Hierarchy



Uniform grid



Adaptive grid: Octree



Question. 3 mn with your neighbors

- Compare 3 accelerations structures:
  - Bounding volumes
  - Uniform grid
  - Octree

Comparison

- Bounding volume:
  - long initial step, fast requests.
- Uniform Grid:
  - fast initial step, fast requests… if proper resolution.
- Octrees:
  - fast and simple initial step, longer requests.

Ray-tracing: advantages

- Slow, but no extra charge for:
  - hidden surface removal,
  - shadows,
  - transparency,
  - texture-mapping (including procedural).
- Inter-reflexions between objects,
- Any graphics primitives,
- Global illumination model.

Ray-tracing: issues

- Limited to Snell-Descartes:
  - all objects are metallic.
- Tree limited to a certain depth:
  - complex objects may be a problem (diamonds, cristal glass)
- Extension: Monte-Carlo Ray-Tracing
  - shoots several rays. slow, but nice.