Accelerated ray tracing

Brian Curless
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Reading

Required:

- Marschner and Shirley, Sections 12.3 (online handout)

Further reading:

Faster ray-polyhedron intersection

Let’s say you were intersecting a ray with a triangle mesh:

Straightforward method

- intersect the ray with each triangle
- return the intersection with the smallest $t$-value.

Q: How might you speed this up?
Bounding Volume Hierarchies (BVHs)

We can generalize the idea of bounding volume acceleration with bounding volume hierarchies (BVHs).

Key: build balanced trees with tight bounding volumes.
Bounding Volume Hierarchies (BVHs)

How do you build a tree?

1. Bottom up: start with individual primitives and gradually cluster them into a tree.

2. Top down: start with one bounding volume around all the primitives and recursively split into two.

Recommendation: go with top down – easier to do, works well.

For top down, how to decide where to split?

Choose a splitting axis and then follow one of these heuristics:

- Find the median of the bounding box centers along the axis and split at that location
- Find the midpoint of the parent bounding box and split there
- Find the split that minimizes the Surface Area Heuristic (SAH) cost:

\[
N_{left} \text{SurfaceArea}(V_{left}) + N_{right} \text{SurfaceArea}(V_{right})
\]

Then move on to the next axis and repeat.
Uniform spatial subdivision

Another approach is **uniform spatial subdivision**.

**Idea:**
- Partition space into cells (voxels)
- Associate each primitive with the cells it overlaps
- Trace ray through voxel array using fast incremental arithmetic to step from cell to cell

**Q:** Given a $10^6$ triangle football stadium with a $10^6$ triangle teapot on one of the seats, would a single uniform spatial subdivision be a good idea?
Non-uniform spatial subdivision: octrees

Another approach is **non-uniform spatial subdivision**. One version of this is octrees:
Non-uniform spatial subdivision: $k$-d trees

Another non-uniform subdivision is $k$-d (k–dimensional) trees:

If the planes can be non-axis aligned, then you get BSP (binary space partitioning) trees.

Various combinations of these ray intersections techniques are also possible.

[Image credits: Wikipedia.]