Accelerated ray tracing

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CSEP 557
Spring 2019

Reading

Required:

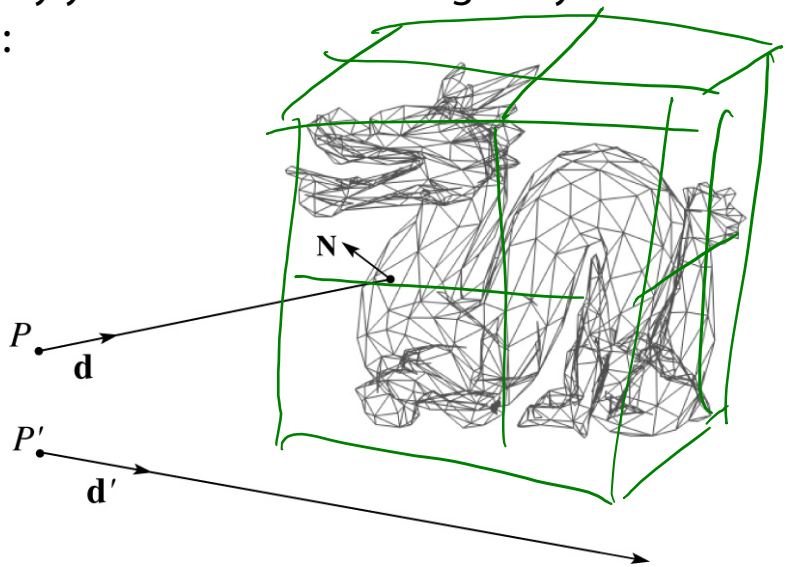
- Marschner and Shirley, Sections 12.3 (online handout)

Further reading:

- A. Glassner. An Introduction to Ray Tracing. Academic Press, 1989.

Faster ray-polyhedron intersection

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



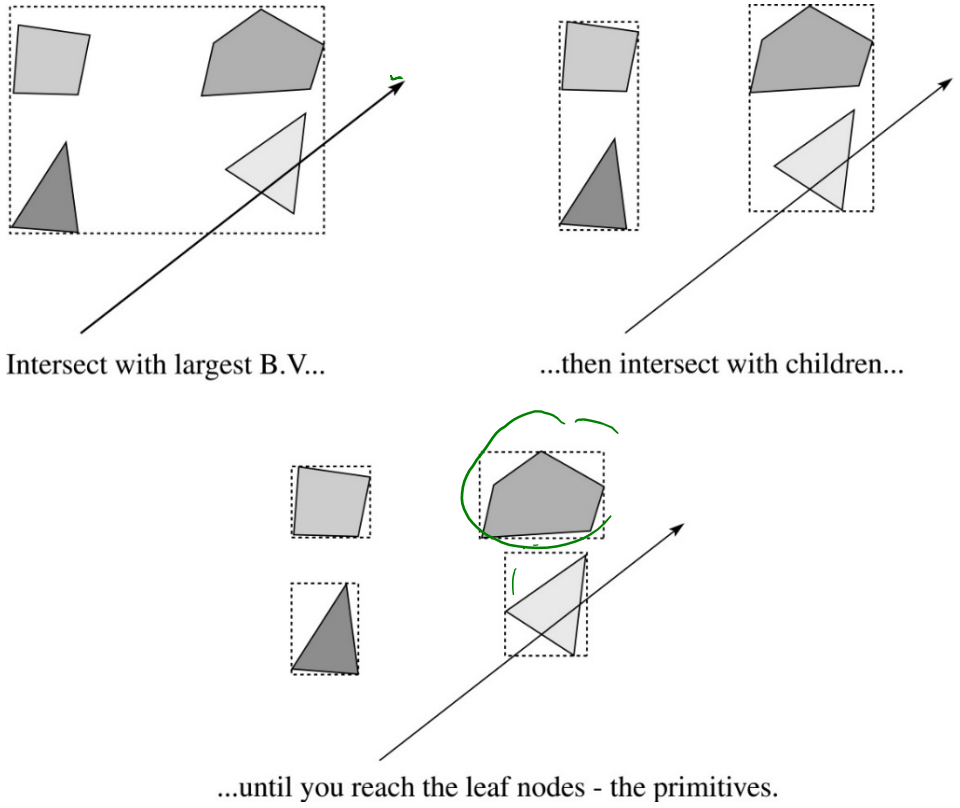
Straightforward method

- 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)

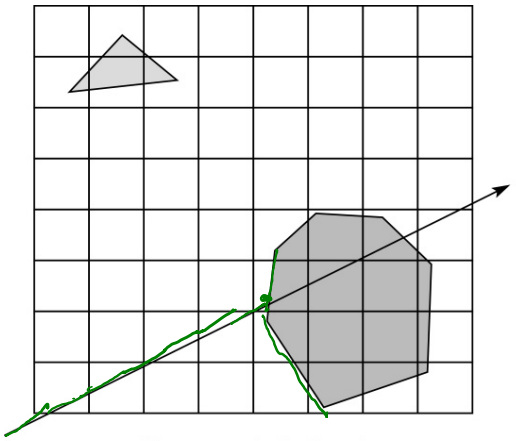
We can generalize the idea of bounding volume acceleration with **bounding volume hierarchies (BVHs)**.



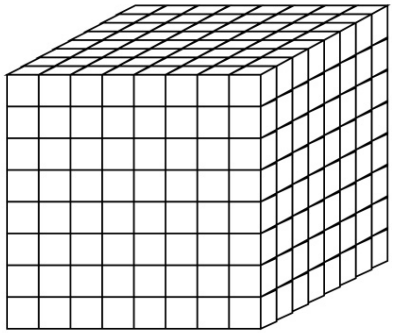
Key: build balanced trees with *tight bounding volumes*.

Uniform spatial subdivision

Another approach is **uniform spatial subdivision**.



Uniform subdivion in 2D



Uniform subdivion in 3D

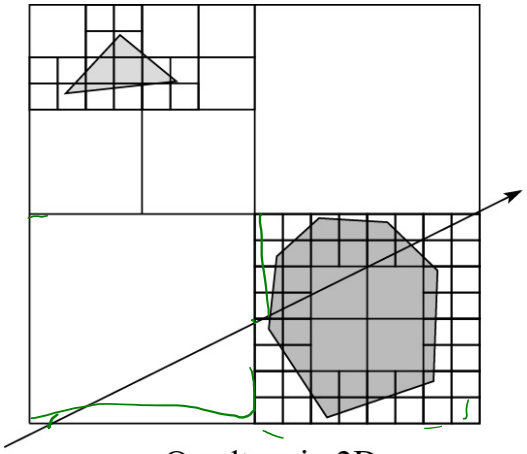
Idea:

- 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

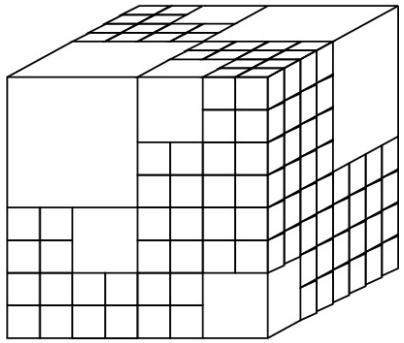
Q: Given a10^6 triangle football stadium with a 10^6 triangle teapot on one of the seats, would a single uniform spatial subdivision be a good idea?

Non-uniform spatial subdivision: octrees

Another approach is **non-uniform spatial subdivision**.
One version of this is octrees:



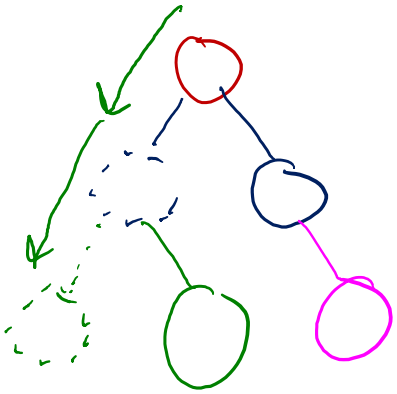
Quadtree in 2D

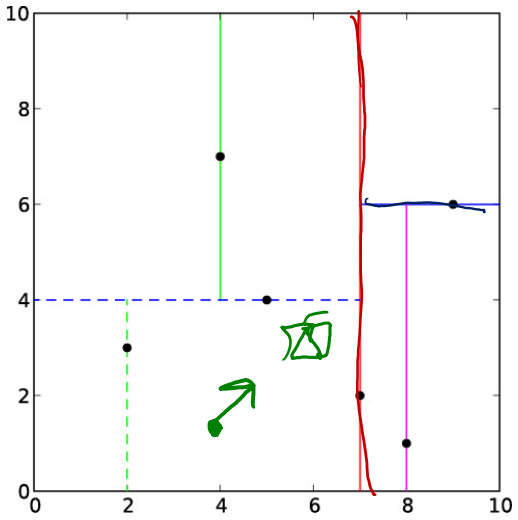


Octree in 3D

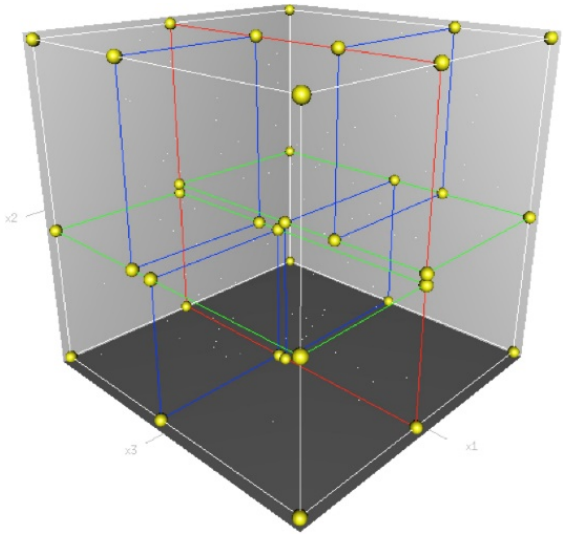
Non-uniform spatial subdivision: *k*-d trees

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





k-d tree ($d = 2$)



k-d tree ($d = 3$)

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.]

Summary

What to take home from this lecture:

- An intuition for how ray tracers can be accelerated.