7. Anti-aliasied and accelerated ray tracing

Reading

Required:

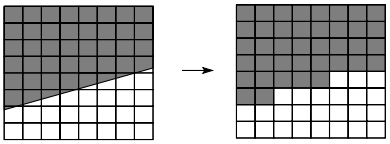
- Watt, sections 12.5.3 – 12.5.4, 14.7

Further reading:

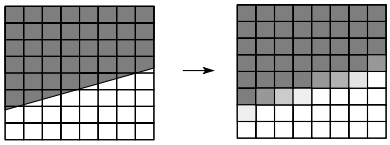
- A. Glassner. An Introduction to Ray Tracing. Academic Press, 1989. [In the lab.]

Aliasing in rendering

One of the most common rendering artifacts is the "jaggies". Consider rendering a white polygon against a black background:



We would instead like to get a smoother transition:

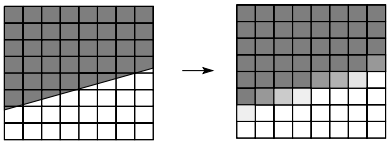


Anti-aliasing

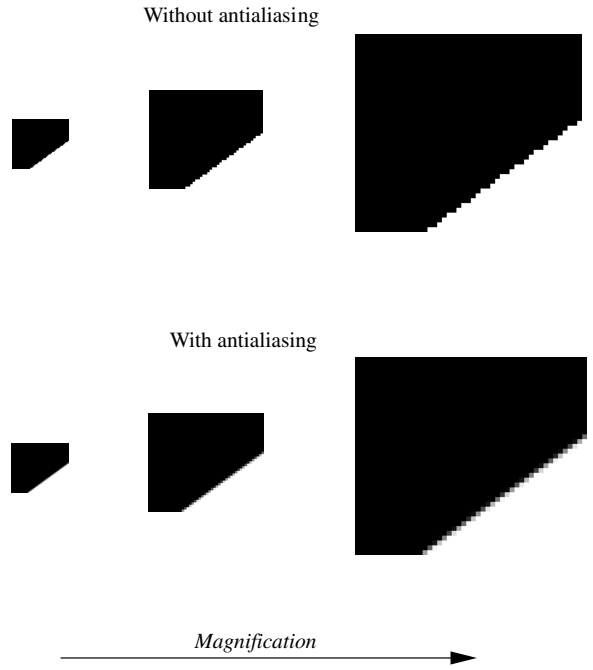
Q: How do we avoid aliasing artifacts?

1. Sampling:
2. Pre-filtering:
3. Combination:

Example - polygon:

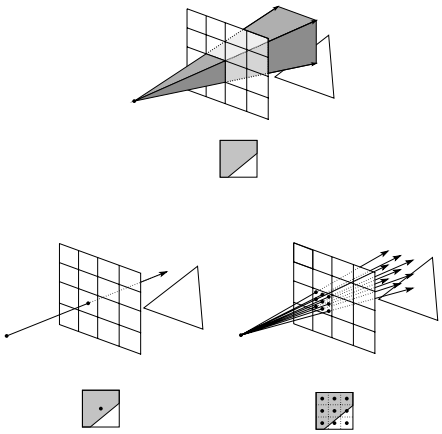


Polygon anti-aliasing



Antialiasing in a ray tracer

We would like to compute the average intensity in the neighborhood of each pixel.



When casting one ray per pixel, we are likely to have aliasing artifacts.

To improve matters, we can cast more than one ray per pixel and average the result.

A.k.a., **super-sampling and averaging down**.

Speeding it up

Vanilla ray tracing is really slow!

Consider: m x m pixels, k x k supersampling, and n primitives, average ray path length of d, with 2 rays cast recursively per intersection.

Complexity =

For m=1,000,000, k = 5, n = 100,000, d=8…very expensive!!

In practice, some acceleration technique is almost always used.

We've already looked at reducing d with adaptive ray termination.

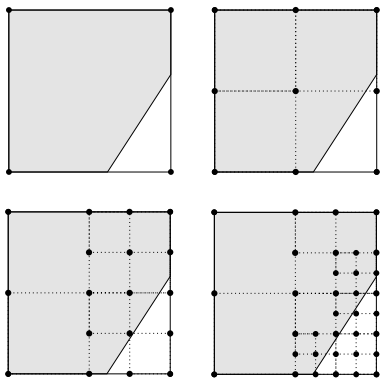
Now we look at reducing the effect of the k and n terms.

Antialiasing by adaptive sampling

Casting many rays per pixel can be unnecessarily costly.

For example, if there are no rapid changes in intensity at the pixel, maybe only a few samples are needed.

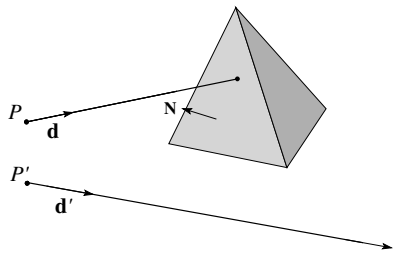
Solution: **adaptive sampling**.



Q: When do we decide to cast more rays in a particular area?

Faster ray-polyhedron intersection

Let's say you were intersecting a ray with a polyhedron:



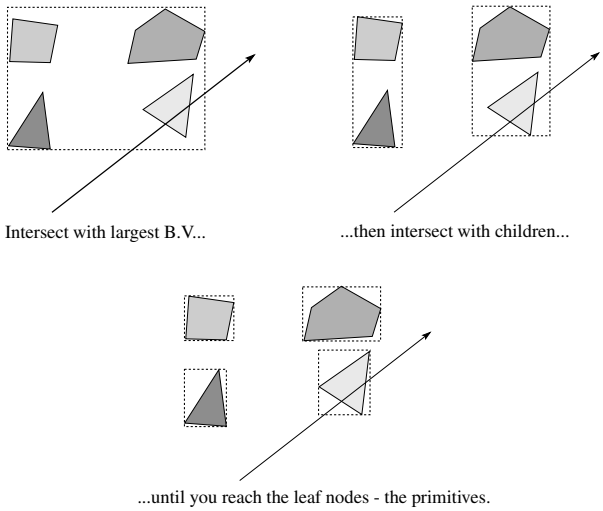
Straightforward method

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

Q: How might you speed this up?

Hierarchical bounding volumes

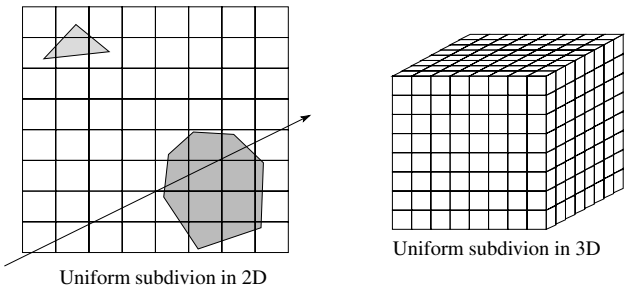
We can generalize the idea of bounding volume acceleration with **hierarchical bounding volumes**.



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

Uniform spatial subdivision

Another approach is **uniform spatial subdivision**.

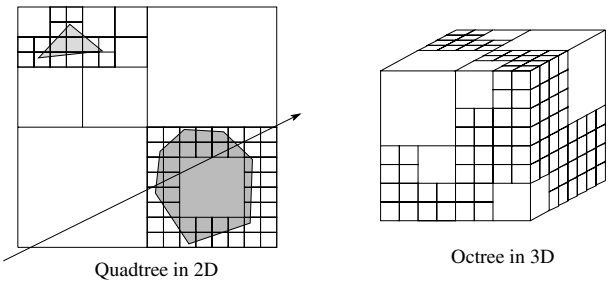


Idea:

- 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

Non-uniform spatial subdivision

Still another approach is **non-uniform spatial subdivision**.



Other variants include k-d trees and BSP trees.

Various combinations of these ray intersections techniques are also possible. See Glassner and pointers on project web page for more.