

Bounding Volume Hierarchies

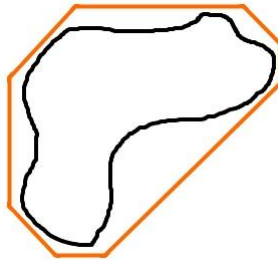
Types of BVHs

Placing meshes entirely within a simple volume can greatly speed up collision detection, because collision only needs to be checked between two volumes instead of thousands of individual triangles.

Types of Bounding Volume Hierarchies (BVH) are:

- Sphere – really fast detection, but loose-fitting
- Axis-aligned Bounding Box (AABB) – aligned to the coordinate axes; also fast
- Oriented Bounding Box (OBB) – oriented to better fit the encompassed geometry
- Ellipsoids
- K-Discrete Orientation Polytopes (*k*-dop) – uses *k* planes to enclose the geometry
- Convex Hull – can be made very tight-fitting, but much more expensive to use
- Swept-Sphere Volumes (SSV) – points, lines, rectangles, triangles

Example of 8-dop in 2D:



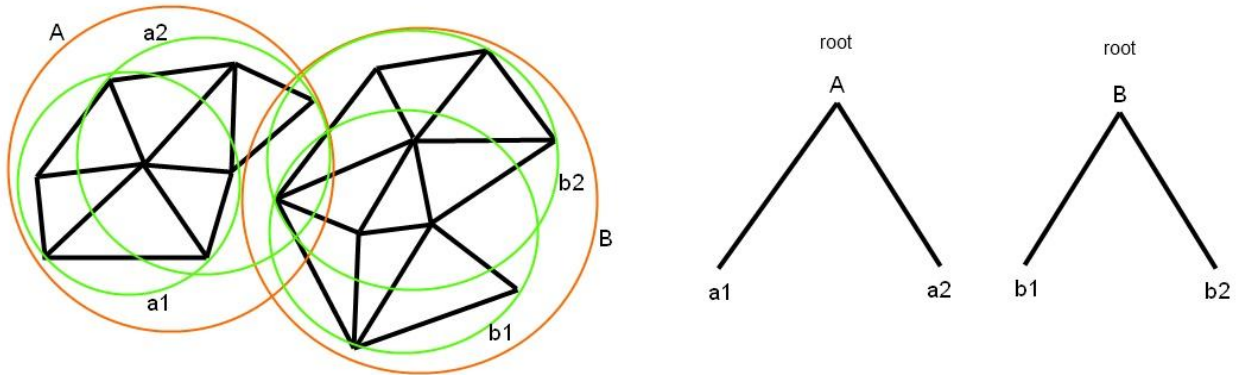
Determining Collisions

Bounding volumes are placed in a binary tree hierarchy, with each node representing a volume containing some portion of the geometry. Child nodes represent volumes that are contained within their parent volume, and leaves represent the smallest volume allowed (perhaps containing 4-5 triangles each).

The process of determining collisions between two BVHs is as follows:

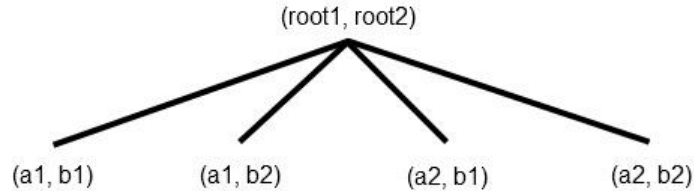
1. Check the roots of the trees for collision; if they're not colliding, then we know that no portion of either object can possibly be colliding and we're done.

2. If the roots *are* colliding, then continue to move down the trees as long as collisions are still detected.
 - This can be accomplished by pushing/popping nodes to/from a queue.
 - Rough estimate: for about 10,000 triangles, the tree will usually have 4-5 levels.
3. If leaf nodes are reached and they're still colliding, then individual triangles must be checked.



Example of spherical bounding volume hierarchy.

A bounding volume test tree can also be used for collision checks. The test tree tells the exact order in which the collision checks should be performed, as shown below:



Commonly Used BVs

Spheres

- Collision is determined by comparing the distance between their centerpoints to the sum of their radii. If the distance is smaller, then the spheres are colliding.

AABBs

- Collision is determined by projecting the boxes onto each axis. If *all* of the projected intervals overlap each other, then a collision has occurred.

OBBs

- Collisions are determined using the Separating Axis Theorem. It has been proven that a maximum of only 15 planes need to be checked against.