CS-184: Computer Graphics
Lecture #7: BSP and AABB Trees

BSP-Trees

• Binary Space Partition Trees
  • Split space along planes
  • Allows fast queries of some spatial relations

• Simple construction algorithm
  • Select a plane as sub-tree root
  • Everything on one side to one child
  • Everything on the other side to other child
  • Use random polygon for splitting plane
BSP-Trees

- Visibility Traversal
  - Variation of in-order-traversal
    - Child one
    - Sub-tree root
    - Child two
  - Select “child one” based on location of viewpoint
    - Child one on same side of sub-tree root as viewpoint

Let’s consider an example…
A Simple Mechanism:
Perform depth-first search and save nodes when we pop them off the search stack.

There are other ways to understand the traversal scheme, but I prefer this one due to its simplicity.
BSP-Trees

Save nodes in order when popped

Remember to 'pop' before traversing children.
BSP-Trees

08-BSPandAABBTrees.key - October 13, 2014
This is a forward-to-backward traversal.
On to another useful space partition...

Your Ray Tracer

RayTrace(image)
  For ray in camera
    image[pixel] = Trace(ray)
Trace(ray)
  t_hit = infinity
  For object in scene
    t_hit = min(object.intersect(ray), t_hit)
  shade at t_hit
  possible calls to Trace(new_ray)
Your Ray Tracer

RayTrace(image)
  For ray in camera
    image[pixel] = Trace(ray)
Trace(ray)
  t_hit = infinity
  For object in scene
    t_hit = min(object.intersect(ray), t_hit)
  shade at t_hit
  possible calls to Trace(new_ray)
That's a lot of monkeys to test

Bounding Shapes

- Bounding shape completely encloses associated object
- Rays cannot hit object w/o intersecting bounding shape
- Two objects cannot collide if shapes don’t overlap
- Tradeoff: Simplicity -vs- tightness
Axis-Aligned Bounding Boxes

- Axis-aligned bounding box defined by min and max x,y,z

Transform box
Not axis-aligned

Min/max of new points
Linear cost to compute.
Axis-Aligned Bounding Boxes

- Min/max of transformed BB points
- Constant time
- Adds slop
- Cumulative slop if multiple transforms occur sequentially

Why would we do this?

Tightness

- Untransformed
- Method (1)
- Method (2)
Box Intersection

Bounding Box of Bounding Boxes
AABB Trees

One of many variations

AABB Trees

One of many variations
AABB Trees
One of many variations

AABB Trees
One of many variations
Ray Test Against Bound Tree

- RayHitSubTree(&ray, node)
  - If RayHitsBB(ray, node.xfBB)
    - ixfray = Inverse(node.xf)*ray
  - If RayHitsBB(ixfray, node.BB)
    - If node is group
      - Foreach child in node.children
        - RayHitSubTree(ixfray, child)
    - else // node not group
      - RayHitGeometry(ixfray, node.geom)
  - ray.collisionInfo.update(ixfray)

Building the tree

- Sort (or QuickSelect) and split on one axis
- Repeat for the other axis
  - x, y, z
Other Schemes

• Uniform Grid/Octrees
• Spatial Hierarchies
• Etc.

Voxels/Octree

• Fun Links
  • http://www.youtube.com/watch?v=6x8fYNFZ41Q
  • http://www.youtube.com/watch?v=Jl54WZtm0QE