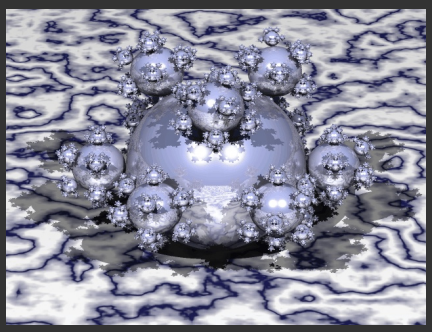
CSE168: Rendering Algorithms Acceleration Structures 3



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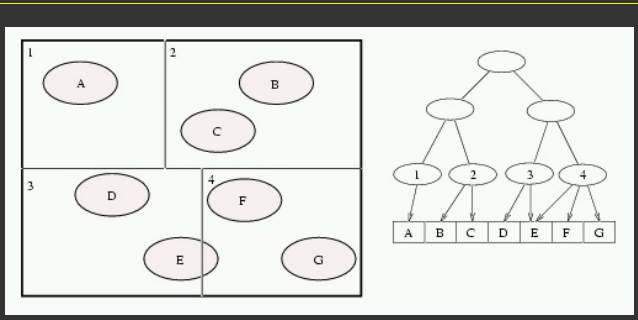
Todays Menu

- Mail boxing
- Cost functions summary
- Grids

Last Time

- BSP trees
- Cost functions

BSP Trees



Mailboxing

- Tag objects to avoid multiple tests with the same ray

Surface Area Heuristic

$$C = \frac{C_n * \sum_n SA_n + C_l * \sum_l SA_l + C_o * \sum_l SA_l * N_l}{SA_{root}}$$

[MacDonald and Booth, 1990]

BVH SAH

$$C = \sum_i \frac{A(i)}{A_{root}} C_{box} + \sum_l \frac{A(l)}{A_{root}} C_{tri}$$

C is total cost of BVH according to SAH.

BVH SAH Construction Step

Use top down splitting approach. Create 2 (in this example) child boxes:

Minimize the following cost:

$$C = 2 * C_{box} + \frac{A_1}{A_c} N_1 C_{tri} + \frac{A_2}{A_c} N_2 C_{tri}$$

Here A_1, A_2, and A_c are the area of child box 1, child box 2, and the current node box.

BVH Configurations

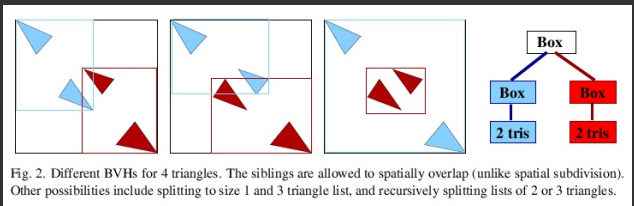
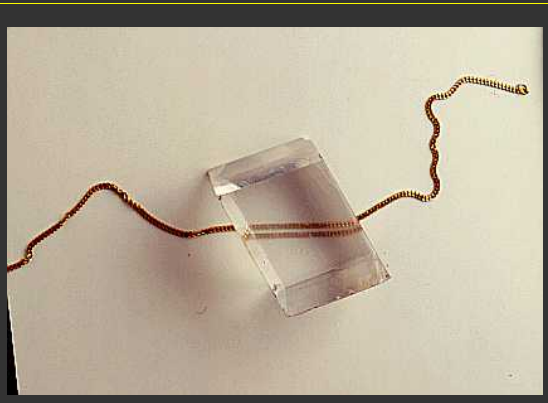


Fig. 2. Different BVHs for 4 triangles. The siblings are allowed to spatially overlap (unlike spatial subdivision). Other possibilities include splitting to size 1 and 3 triangle list, and recursively splitting lists of 2 or 3 triangles.

What is this?



Spatial Subdivision

- Subdivide all space into cells
- Cells can be empty
- Fast traversal algorithms
- Objects are checked in order

Spatial Subdivision

- Octrees
  [Glassner, IEEE CG&A 1984]
- Grids
  [Fujimoto et al., "ARTS", 1986]
- Hierarchical grids
- Adaptive Grids
  [Klimaszewski and Sederberg, IEEE CG&A 1997]

Grids

- Building a grid
  Bounding box, resolution…
- Traversing a grid (3D-DDA)

Building a Grid

- Find grid bounding box
- Make grid cells (voxels)
- Insert triangles into grid

Triangle-Voxel Intersection

- Vertices outside box test
- Vertices inside box test
- Triangle-edge box intersection test
- Box diagonal triangle intersection test

Triangle Lists

```
struct cell {
  int ntriangles;
  int *triangles;
}
```

OR

```
struct cell {
  int *triangles;
}
```


Grid Traversal

Step through grid using 3D-DDA

- Find line through grid
- Test all cells along this line

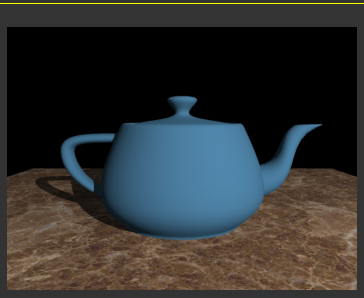
Grid Traversal 2D

```
Intersect grid bounding box
compute t_xmin, t_xmax, t_ymin, and t_ymax

if (t_xmin > t_ymin) {
  // hit x side
  i = 0
  y = o_y + t_xmin * d_y
  j = ( y - y_min ) / (y_max - y_min) * n_y

  dtx = (t_xmax - t_xmin) / nx
  dty = (t_ymax - t_ymin) / ny
  t_xnext = t_xmin + dtx
  t_ynext = t_ymin + (j+1)*dty
}
```

Grid Traversal 2D cont'd

```
while (1) {
  cell_index = j*n_y + i
  intersect objects in cell[ cell_index ]
  if (t_xnext < t_ynext) {
    t_xnext += dtx
    i += 1
    if (i == n_x) break;
  } else {
    t_ynext += dty
    j += 1
    if (j == n_y) break;
  }
}
```


Grid Statistics



No grid: 6321 intersection tests per ray (total = 3710882127)

One grid: 44.86 intersection tests per ray (total = 26336575)

Hierarchical Grids

- Scenes have varying density of objects
- Use subgrids in dense areas

HG Statistics

No grid: 6321 intersection tests per ray (total = 3710882127)

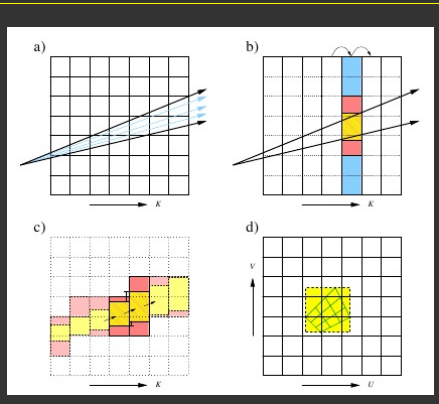
One grid: 44.86 intersection tests per ray (total = 26336575)

2-level grid: 12.05 intersection tests per ray (total = 7072774)

Adaptive Grids

- Scenes have varying density of objects
- Use compact grids in dense areas
- Grid merging

Coherent Ray Tracing of Grids



Coherent BVH Ray Tracing

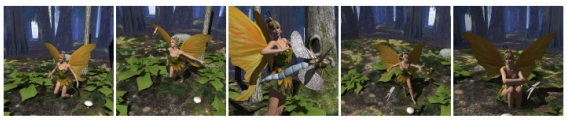


Fig. 1. Screenshots from an animated 180,000 triangle scene with moving dragonfly, fairy, and plants. At 1024×1024 pixels the animated scene is ray traced at roughly 3.7 frames per second on a dual-2.6 GHz Opteron desktop PC including shadows and texturing.

Dynamic BVH Ray Tracing

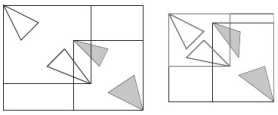
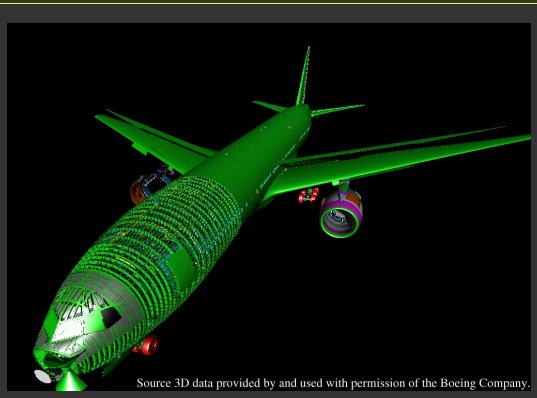


Fig. 5. When the objects move, a BVH can keep the same hierarchy, and only needs to update the bounding volumes. Though the new hierarchy may not be as *good* as the old one, it will always be *correct*; for all but some worst-case examples, even severe deformations did not significantly deteriorate the BVH quality. By considering different primitive positions during the build, we can also make sure that the chosen BVH will be reasonably good for scenes in which a good hierarchy is not apparent from a single pose.

Ray Tracing Large Models



Boeing 777 - 360 million triangles

Next time

Texture mapping, environment mapping, bump mapping