CS 112 - Collision Detection

Computationally Expensive

- Objects have millions of triangles
- For two objects with m and n triangles
  - You need mn triangle-triangle intersections
  - $10^{12}$ intersection computations for just two objects
- Dynamic scenes – 30 frames per second
  - Humongous computation needs
- Need to make it efficient
Efficiency Measures

- Most of the time objects do not intersect
  - Fast rejections
  - Spend time on intersection computations only when objects intersect
- Two important issues
  - Bounding Volume – How closely it approximates the object?
  - Intersection Computation – How simple are the intersection computations?

Bounding Volumes

- Enclose the object
- The ratio of the object volume to the bounding volume should be as close to 1 as possible
- Depends on the shape of the object
Bounding Volumes

- **Axis-aligned**
  - The planes of the box is aligned with the *world coordinates*

- **Object oriented**
  - The planes are aligned to hug the object more closely
  - More rejections

Bounding Volumes

- **Spherical**
  - Enclosing *sphere*

- **Spherical Shells**
  - Between *concentric spherical shells*

- **Convex Hull**
  - Closest Fit (Optimal)
  - Smallest Ratio
Intersection Calculations

- Axis aligned Bounding Box
  - Compare min and max in X, Y and Z directions
  - If all of them intersect, then the object intersects

- Spherical
  - Find the distance between the spheres
  - If less than the summation of the radius, then intersects

Intersection Computations

- Object Oriented and Spherical Shells
  - Complex computations
  - References in course website

- Convex Hull
  - Convex hull of the object is the object itself
  - Therefore, need exhaustive triangle-triangle computation
Updating the bounding boxes

- Axis aligned Bounding box
  + Translation invariant
  - Any other kind of movements, box no longer remains axis-aligned
  - Needs to be recomputed frame by frame
  + Very simple computation

- Spherical
  + Transformation invariant
  + Simple intersection computation
  - Lot of empty space in the volume

- Oriented Bounding Box
  + Transformation invariant
  - Complex intersection computation
  + Compact volume
Hierarchical Bounding Volumes

- Similar to spatial subdivision
- But for each object
- Slightly different
  - Union of children may not encompass the parent

If does not intersect, do not explore the children
If intersects, do bounding volume intersection on children
Continue till you get to the triangle-triangle intersection
  - Very few of them needs to be computed