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
  - Humungous computation needs
- Need to make it efficient

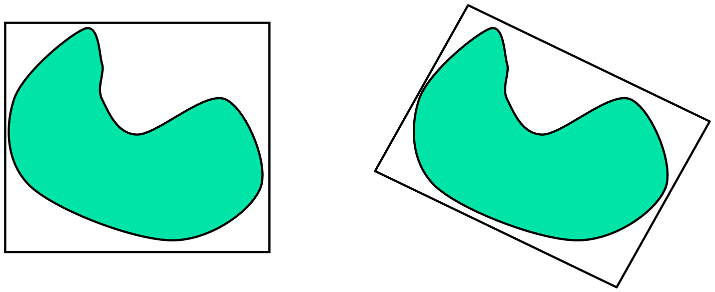
Efficiency Measures

- 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

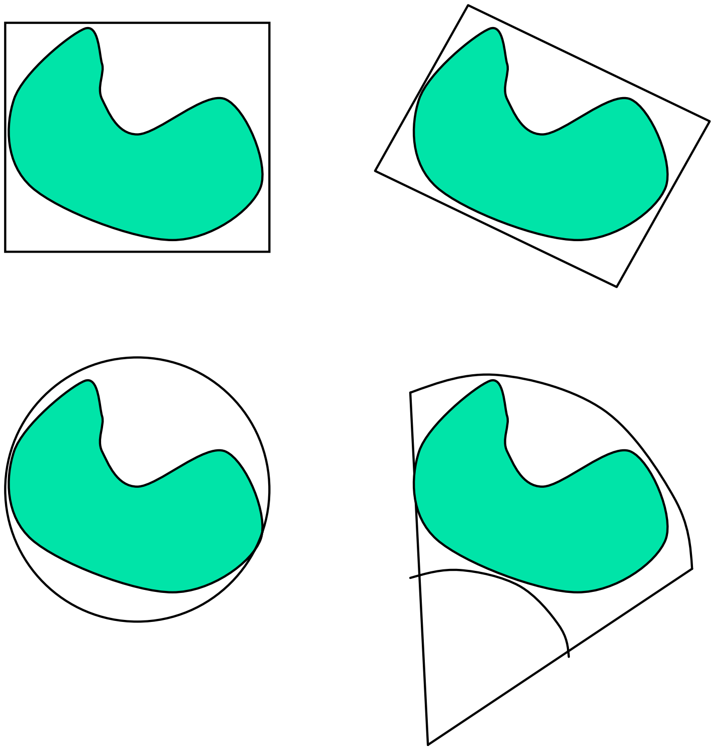
Bounding Volumes



- 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
  - Google for reference
- 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

Updating the bounding boxes

- Spherical

  +Transformation invariant

  +Simple intersection computation

  - Lot of empty space in the volume

- Oriented Bounding Box

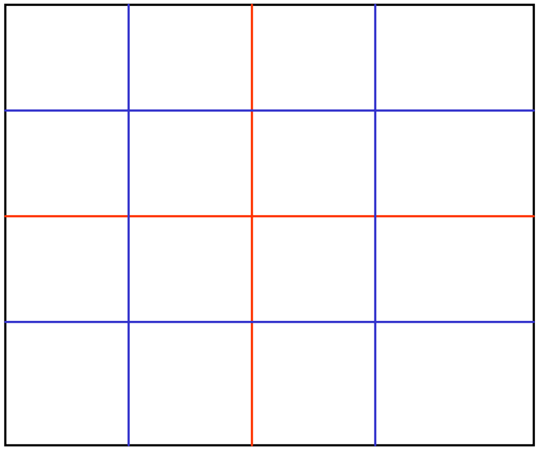
  + Transformation invariant

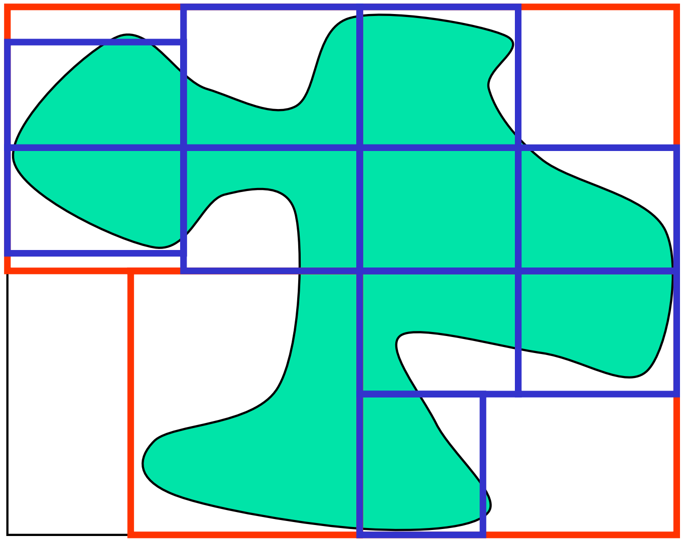
  - Complex intersection computation

  + Compact volume

Hierarchical Bounding Volumes

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





Hierarchical Bounding Volumes

- 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