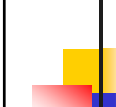


# CS 112 - Collision Detection

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## 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

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## 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?

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## 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

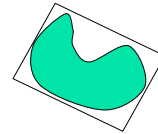
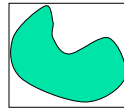
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## Bounding Volumes

- 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



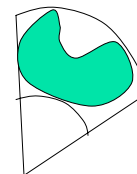
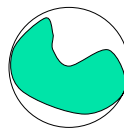
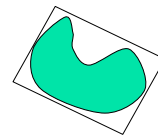
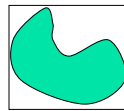
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## Bounding Volumes

- Spherical
  - Enclosing *sphere*
- Spherical Shells
  - Between *concentric spherical shells*
- Convex Hull
  - Closest Fit (Optimal)
  - Smallest Ratio



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## 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

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## 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

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## 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

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## 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

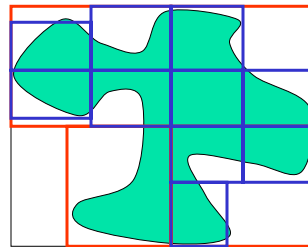
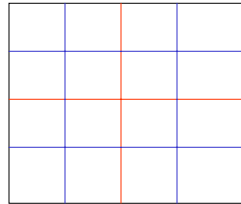
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## Hierarchical Bounding Volumes

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



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## 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

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