Collision Detection

15-493
Computer Game Programming

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Geometric Proximity Queries Frequently Encountered

Given two geometric objects, determine:

- If they intersect with each other?
- If they do not interpenetrate each other, how far are they apart?
- If they define volumes, do they overlap?

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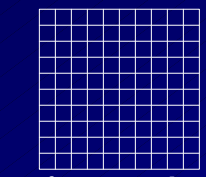
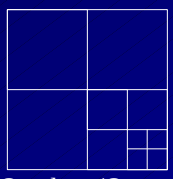
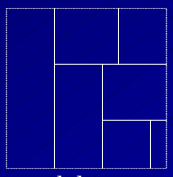
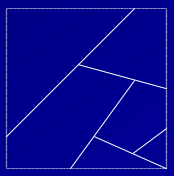
Spatial Data Structures & Subdivision


Uniform Spatial Sub


Quadtree/Octree


kd-tree


BSP-tree

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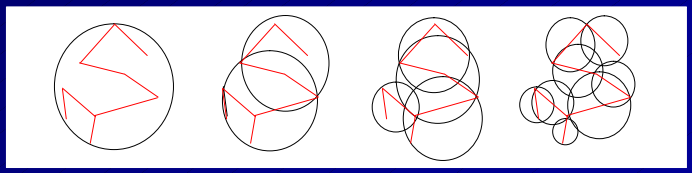
Bounding Volume Hierarchies

- Model Hierarchy:
  - Simple volume that bounds a set of triangles
  - Nodes bound a subset of the parent's triangles
  - Leaves contain individual triangles
- Sample Binary BVH:



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Example Bounding Volumes

- Spheres
- Ellipsoids
- Axis-Aligned Bounding Boxes (AABB)
- Oriented Bounding Boxes (OBBs)
- Convex Hulls
- *k*-Discrete Orientation Polytopes (*k*-dop)
- Spherical Shells
- Swept-Sphere Volumes (SSVs)

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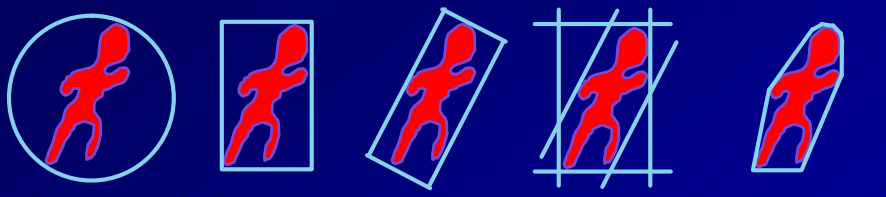
Trade-off in Choosing BV's



Increasing:

- Complexity
- Tightness of Fit
- Cost of overlap test

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Sphere Tree Hierarchy

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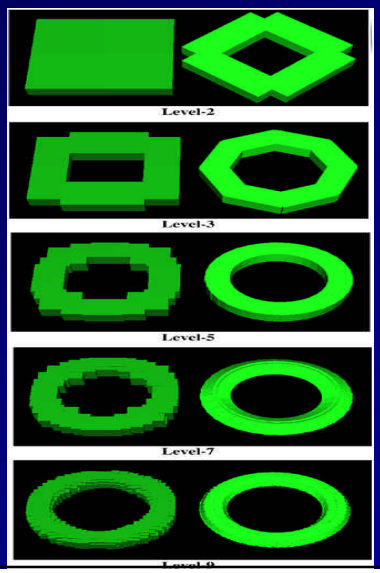
Example: AABB's vs. OBB's



Approximation of a Torus

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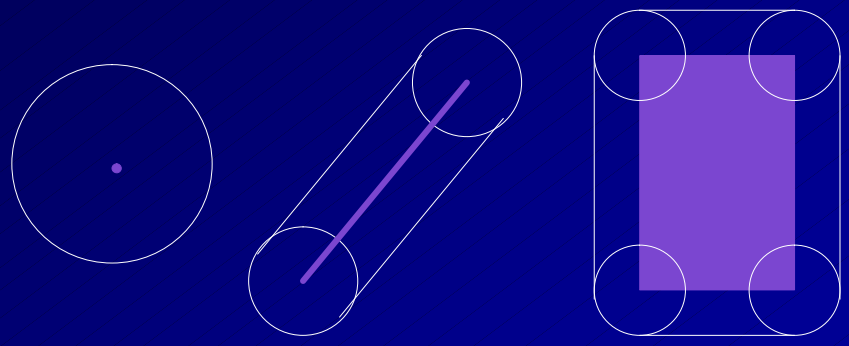
Hybrid Hierarchy of Swept Sphere Volumes



PSS LSS RSS

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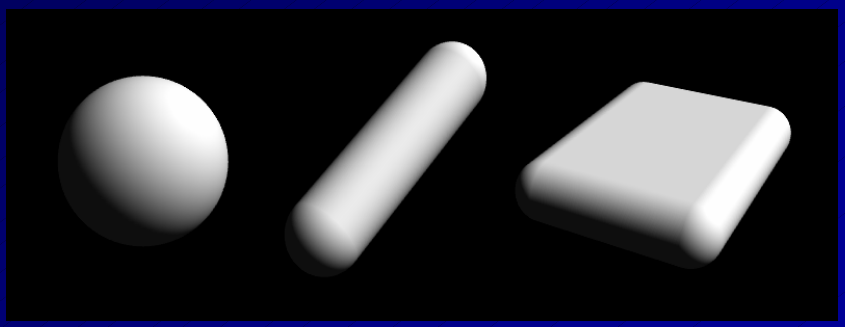
Swept Sphere Volumes (S-topes)



PSS **LSS** **RSS**

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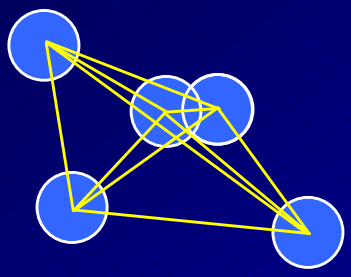
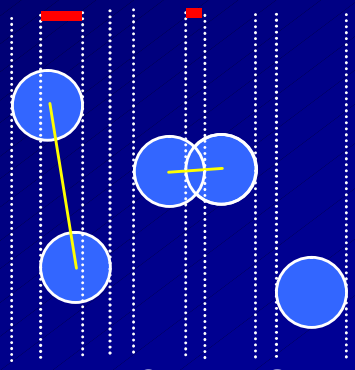
Collision Detection: Broad Phase vs Narrow Phase



BROAD PHASE:
Determine Which Pairs to Check



NARROW PHASE :
Actually Calculate Individual Pair Tests

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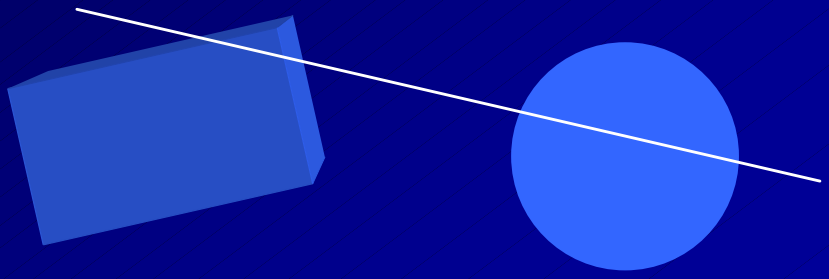
Intersection Tests for Boxes, Spheres, and Planes

- Frequently Used in Games
- Relatively Simple and Cheap to Compute



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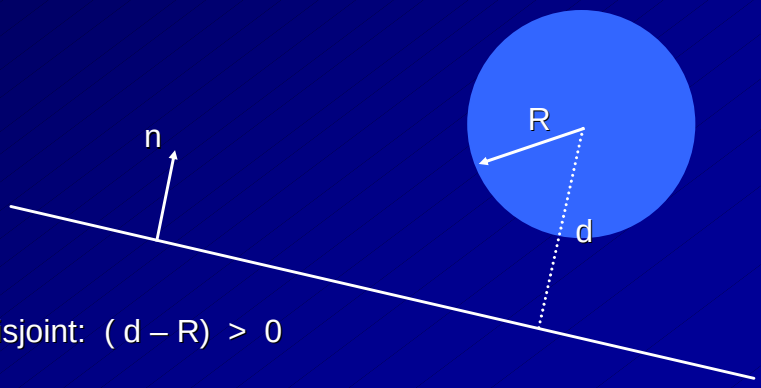
Sphere-Plane Intersection

- Distance from Sphere Center to Plane



Disjoint: (d – R) > 0

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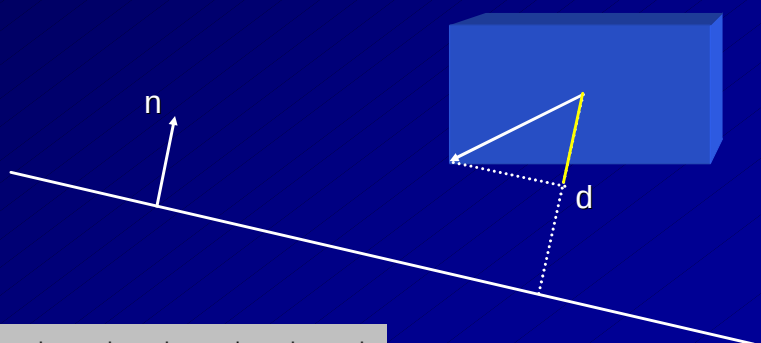
Box-Plane Intersection

- Distance from Box Center to Plane



$$|d| \le a_1|\mathbf{n}\cdot\mathbf{A}^1| + a_2|\mathbf{n}\cdot\mathbf{A}^2| + a_3|\mathbf{n}\cdot\mathbf{A}^3|$$

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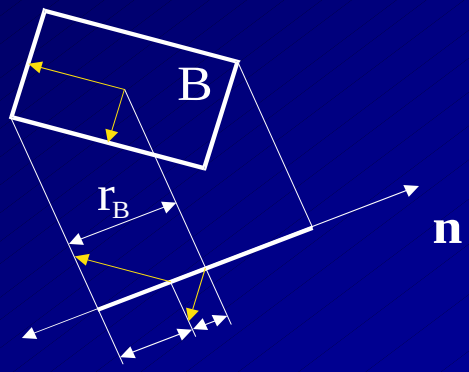
OOBB-OOBB Overlap Test

- Half-length of interval is sum of box axis projections.



$$r_B = b_1\left|\mathbf{R}_1^B \cdot \mathbf{n}\right| + b_2\left|\mathbf{R}_2^B \cdot \mathbf{n}\right| + b_3\left|\mathbf{R}_3^B \cdot \mathbf{n}\right|$$

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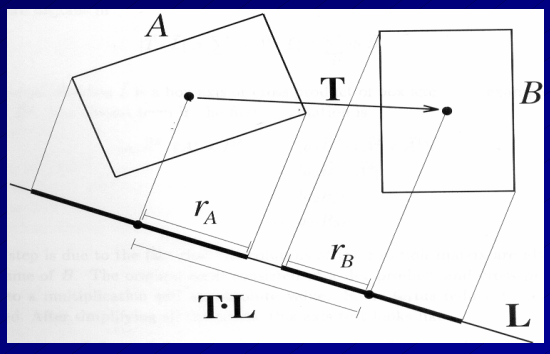
OBB Separating Axis Theorem



Without overlap **T** * **L** > $r_A + r_B$

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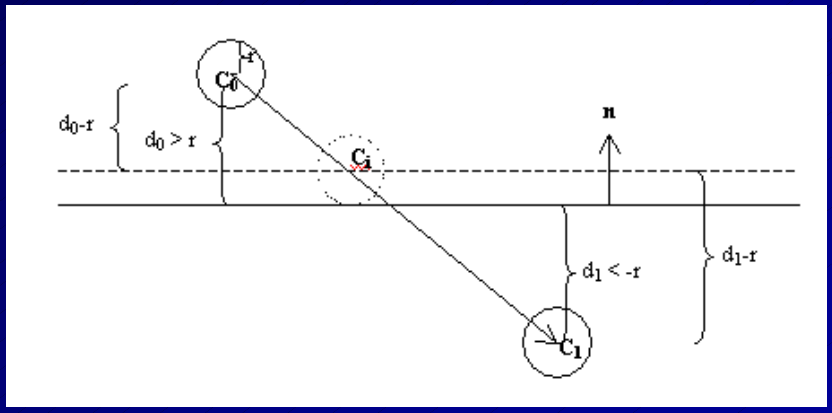
Sphere-Plane Sweep Test



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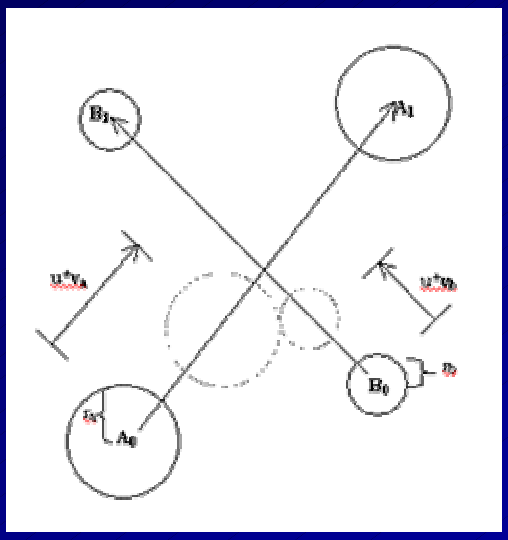
Sphere-Sphere Sweep Test



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Colliding Two Object Hierarchies

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Collision Detection Software

University of North Carolina (UNC) at Chapel Hill is a leader in geometric proximity query research and has many software packages available to students and educators

http://www.cs.unc.edu/~geom/collide/

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Final Fantasy XI

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Resident Evil Zero

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Tomb Raider :
Angel of Darkness