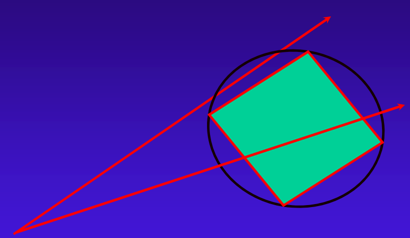
Bounding Volumes



Bounding Volumes

Use simple volume

enclose object(s)

if ray doesn't intersect volume
it doesn't intersect what's inside

tradeoff for rays where there is
extra intersection test for
- object intersections
- volume intersections, but not object intersections

v.
quick test for no intersection for no volume intersection

Bounding Volumes

3 approaches:
- Bound object
- Bound screen area that object projects to
- Bound area of world space

Can use hierarchical organization of bounding volumes

Bound Object

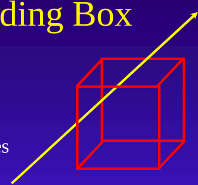
Easy-to-compute approximation to object

Easy to test for ray-bounding-object intersection

Trade-off complexity of computation v. tightness of fit

Can bound object in object space or world space

Axis Aligned Bounding Box



Easiest bounding volume to compute

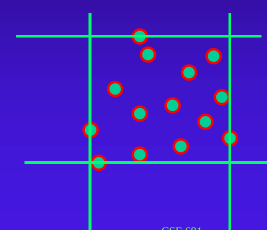
Compute min/max for x, y, z of vertices

Some computational expense to test for intersection

Not tight fitting for some objects

Axis-Aligned Bounding box

```
limit[3][0] = 10000000000; limit[3][1] = -1000000000;
for each point, for each dimensions
        if p[i][j] < limit[j][0] then limitIndex[j][0] = i;
        if p[i][j] > limit[j][1] then limitIndex[j][1] = i;
```



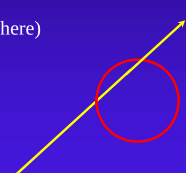
Bounding Spheres

Takes some effort to compute optimal bounding sphere

Easy to compute approximation (non-optimal fit)

Easy to test for intersection (ray-sphere)

Not tight fitting for some objects

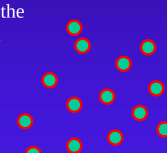


Bounding Spheres

Loop through points and record min/max in x,y,z

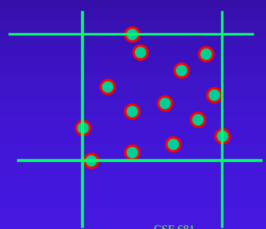
Use maximally separated pair of points and their midpoint as initial approximation to sphere

For each point in original set, adjust the bounding sphere to include the point



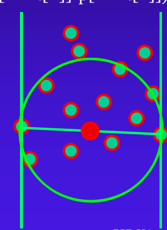
Bounding Spheres

```
limit[3][0] = -10000000000; limit[3][1] = 1000000000;
for each point, for each dimensions
        if p[i][j] < limit[j][0] then limitIndex[j][0] = i;
        if p[i][j] > limit[j][1] then limitIndex[j][1] = i;
```



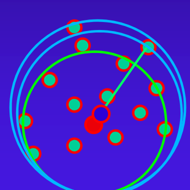
Bounding Spheres

```
k=0;
if (|limit[1][1]-limit[1][0]| > |limit[0][1]-limit[0][0]| ) k=1;
if (|limit[2][1]-limit[2][0]| > |limit[k][1]-limit[k][0]| ) k=2;
midpoint = (p[limit[k]]+p[limit[k]])/2;
radius = (p[limit[k]]-p[limit[k]])/2;
```

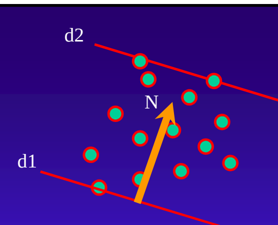


Bounding Spheres

- For each point
  - if p[i] is outside of radius of midpoint
  - radius = (radius + dist(midpoint,p[i]))/2
  - center = p[i]+radius*(center-p[i])/|center-p[i]|;



Bounding Slabs



For each slab, user defines normal to use for slab pair

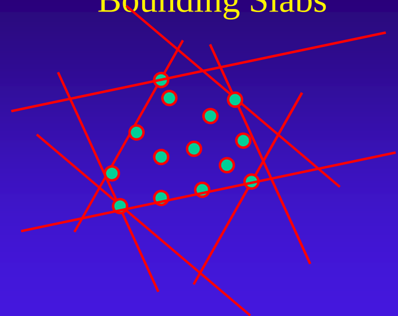
For each object, compute 2 d's for each N

Takes some effort to compute d's - how?

Takes some effort to test for intersection - how?

Can add more slabs to get tighter fit

Bounding Slabs

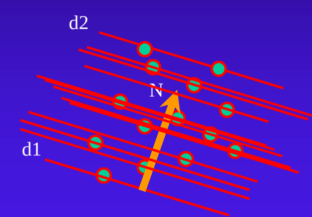


Bounding Slabs

SLAB: pair of parallel planes

for all points, compute P•N = d

find min, max d for all points



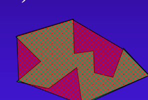
Bounding Slabs

Slab defined by: N, d1, d2

- ray defined by P(t) = P+tD
- intersection with plane: N.P + t(N.D) = d
- for each slab
  - retrieve d1, d2, N
  - compute
    - t1 = (d1-N.P)/(N.D); t2 = (d1-N.P)/(N.D)
    - keep track of entering max, exiting min
    - how to determine entering, exiting status?

Convex Hull

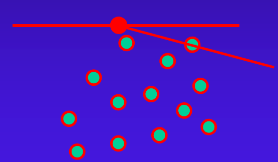
Smallest convex polyhedron containing object (point set)



Takes some effort to test for intersection - how?

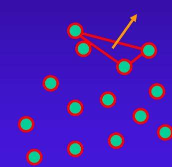
Convex Hull

Find highest vertex
Find plane through vertex parallel to ground plane
Find second vertex that makes minimum angle with
first vertex and up vector



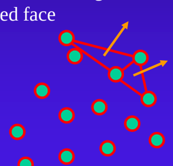
Convex Hull

Find third vertex that makes plane whose normal makes
minimum angle with up vector



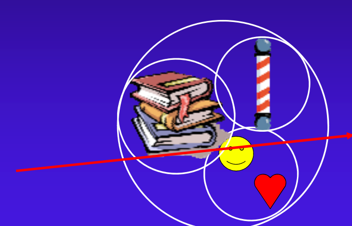
Convex Hull

In the final convex hull, each edge will be shared by two and only two triangles
For each unmatched edge (until there are no more),
find vertex that, when a triangle is formed with the edge, will minimize angle between its normal and normal of shared face



Hierarchical Bounding Volumes

Compute bounding volume for groups of objects



Compute bounding volume for groups of groups of objects

Test higher-level bound volumes first

Bound Area of Projection

Project object to picture plane

Bound colums and rows that object projects to

Only intersect first-level rays with pixels in projected area
i.e., only good for ray-casting part of ray-tracing

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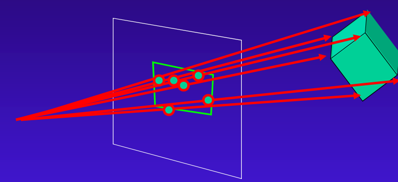
Bound Area of Projection



Project vertices onto picture plane

Find 2D bouding box on picture plane

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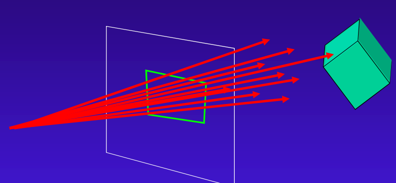
Bound Area of Projection



Project rays through pixels inside bound

Only test object that was bounded

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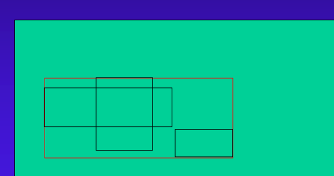
Bound Area of Projection

Areas of projection can be grouped hierarchically



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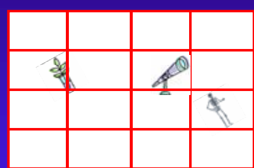
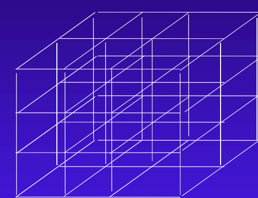
Bound Area, not Object

In 2D - it looks like this:



Bucket sort objects into cells

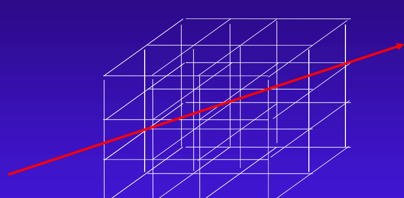
Bound Area of 3D World



Divide world space into cells

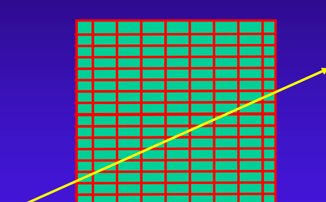
Dump objects into cells: an object is dumped into each cell it touches

Bound Area of World



Trace ray through cells from closest to farthest
Intersect ray with each object in cell
Stop when it hits closest object in cell

Bound Area of World



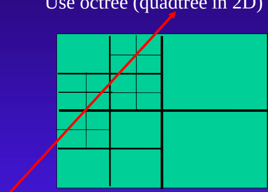
Traverse cells in order – test all objects in cell

If no intersections, step to next cell

If one or more intersections, get closest intersection

Bound Area of World

Use octree (quadtree in 2D)



Hierarchical approach: cells, then subcells..

Takes significant coding to keep track of level

Overhead in popping up and down in hierarchy

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Binary Spatial Partitioning

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