Ray tracing complexity

O(# of intersection tests) = O(#pixels x # objects)

Can we reduce the number of intersection tests?

Optimization

- bounding boxes
- oct-trees
- BSP-trees

Bounding boxes: intuition

Most rays miss the object

Bounding boxes

1. Rule out rays by simple intersection test with bounding box
2. Perform exhaustive test on remaining rays

Bounding boxes & hierarchical coordinates

- Body xfm
- Body description
  - Head translate wrt body
  - Head rotate
  - Head description
    - (Eye1 translate wrt head
      - Eye1 scale
      - Eye1 description)
    - (Eye2 translate wrt head
      - Eye2 scale
      - Eye2 description)

- Eye bounding box

Bounding boxes & hierarchical coordinates

- Box defined by extrema of primitive:
  - x_min
  - x_max
  - y_min
  - y_max
  - z_min
  - z_max

Can you compute these for our primitives?
bounding boxes & hierarchical coordinates

body xfm
body description
  head translate wrt body
  head rotate
  head description
    (eye1 translate wrt head
     eye1 scale
     eye1 description)
    (eye2 translate wrt head
     eye2 scale
     eye2 description)

transformed box defined by
transformed corners $(x_{min}, y_{min}, z_{min}), (x_{max}, y_{max}, z_{max})$.

bounding boxes & hierarchical coordinates

body xfm
body description
  head translate wrt body
  head rotate
  head description
    (eye1 translate wrt head
     eye1 scale
     eye1 description)
    (eye2 translate wrt head
     eye2 scale
     eye2 description)

scene graph node
compute extrema based on local primitive and the extrema of children's transformed bounding boxes.

bounding boxes & hierarchical coordinates

body xfm
body description
  head translate wrt body
  head rotate
  head description
    (eye1 translate wrt head
     eye1 scale
     eye1 description)
    (eye2 translate wrt head
     eye2 scale
     eye2 description)

bounding box based on head and bounding boxes of eyes.

bounding boxes & hierarchical coordinates

body xfm
body description
  head translate wrt body
  head rotate
  head description
    (eye1 translate wrt head
     eye1 scale
     eye1 description)
    (eye2 translate wrt head
     eye2 scale
     eye2 description)
bounding boxes & hierarchical coordinates

body xfm
body description
  head translate wrt body
  head rotate
  head description
    (eye1 translate wrt head
     eye1 scale
     eye1 description)
    (eye2 translate wrt head
     eye2 scale
     eye2 description)

intersection

body xfm
body description
  head translate wrt body
  head rotate
  head description
    (eye1 translate wrt head
     eye1 scale
     eye1 description)
    (eye2 translate wrt head
     eye2 scale
     eye2 description)

bounding box intersection

1. find intersection of ray with each bounding plane of box

bounding box intersection

x=left, x=right, y=bottom, y=top, z=front, z=back

front plane intersection:
q = p+(?,?,front)
q = (px+αvx,py+αvy,pz+αvz)
where α = (front-pz)/vz

intersection

body xfm
body description
  head translate wrt body
  head rotate
  head description
    (eye1 translate wrt head
     eye1 scale
     eye1 description)
    (eye2 translate wrt head
     eye2 scale
     eye2 description)

bounding box intersection

2. determine if any intersection point is on box

bounding box intersection

x=left, x=right, y=bottom, y=top, z=front, z=back

q = (x0,y0,z0)
Is left ≤ x0 ≤ right and bottom ≤ y0 ≤ top and back ≤ z0 ≤ front?
bounding box intersection test

- scene graph node
  - if ray intersects with node's bounding box, check for intersection with local object and pass ray to children; otherwise return no intersection

REMEMBER: bounding box encloses objects at node and all bounding boxes of children

optimization

- bounding boxes
- oct-trees
- BSP-trees

We won't cover these. Look on the web for details.