

ray tracing complexity

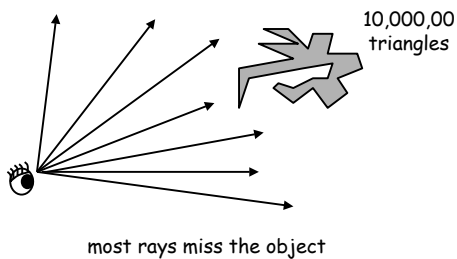
$O(\# \text{ of intersection tests})$
 $= O(\# \text{ pixels} \times \# \text{ objects})$

Can we reduce the number of intersection tests?

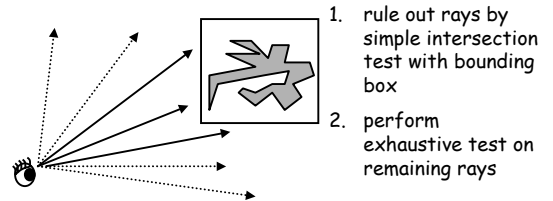
optimization

- bounding boxes
- oct-trees
- BSP-trees

bounding boxes: intuition

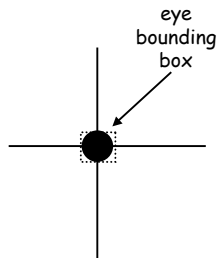


bounding boxes



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} ←

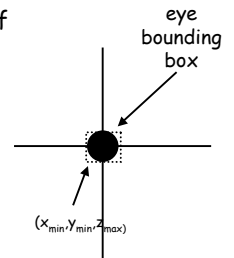


bounding boxes & hierarchical coordinates

box defined by extrema of primitive:

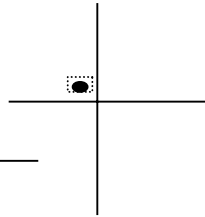
- x_{\min}
- x_{\max}
- y_{\min}
- y_{\max}
- z_{\min}
- z_{\max}

can you compute these for our primitives?



bounding boxes & hierarchical coordinates

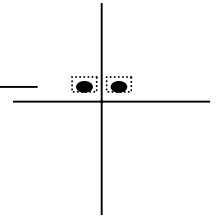
```
body xfm
body description
  head translate wrt body
  head rotate
  head description
    {eye1 translate wrt head
    eye1 scale
    eye1 description}
    {eye2 translate wrt head ←
    eye2 scale
    eye2 description}
```



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

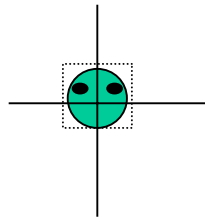
bounding boxes & hierarchical coordinates

```
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}
```

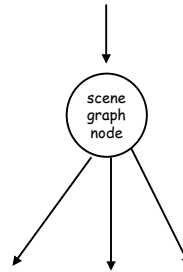


bounding boxes & hierarchical coordinates

```
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}
```



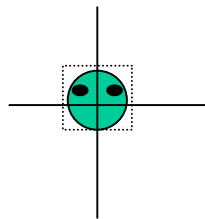
bounding boxes & hierarchical coordinates



compute extrema based on local primitive and the extrema of children's transformed bounding boxes

bounding boxes & hierarchical coordinates

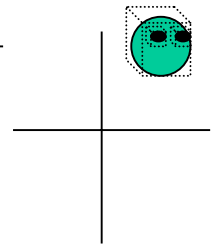
```
body xfm
body description
  head translate wrt body
  head rotate
  head description ←
    {eye1 translate wrt head
    eye1 scale
    eye1 description}
    {eye2 translate wrt head
    eye2 scale
    eye2 description}
```



bounding box based on head and bounding boxes of eyes

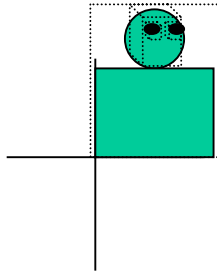
bounding boxes & hierarchical coordinates

```
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}
```



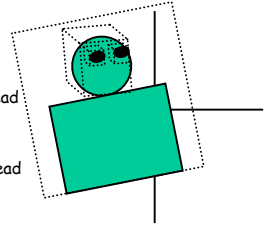
bounding boxes & hierarchical coordinates

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}



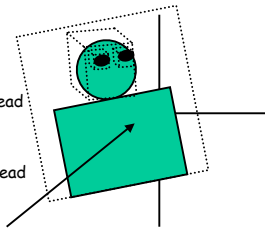
bounding boxes & hierarchical coordinates

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}



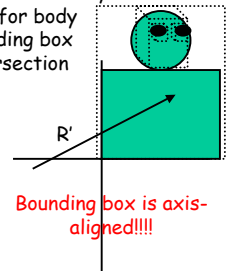
intersection

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}



intersection

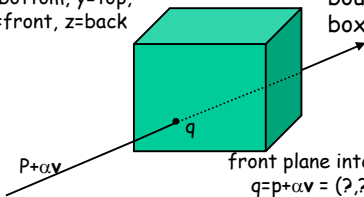
body xfm ← Apply inverse transform to ray
 body description ← Test for body bounding box intersection
 head translate wrt body
 head rotate
 head description
 {eye1 translate wrt head
 eye1 scale
 eye1 description}
 {eye2 translate wrt head
 eye2 scale
 eye2 description}



bounding box intersection

$x=\text{left}, x=\text{right},$
 $y=\text{bottom}, y=\text{top},$
 $z=\text{front}, z=\text{back}$

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



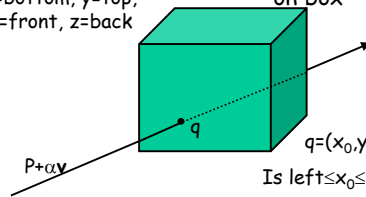
front plane intersection:
 $q=p+\alpha v = (\text{?, ?}, \text{front})$

$q=(p_x+\alpha v_x, p_y+\alpha v_y, p_z+\alpha v_z)$
 where $\alpha = (\text{front}-p_z)/v_z$

bounding box intersection

$x=\text{left}, x=\text{right},$
 $y=\text{bottom}, y=\text{top},$
 $z=\text{front}, z=\text{back}$

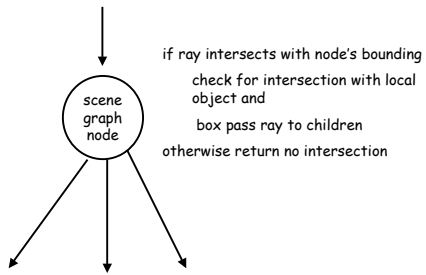
2. determine if any intersection point is on box



$q=(x_0, y_0, z_0)$

Is $\text{left} \leq x_0 \leq \text{right}$ and
 $\text{bottom} \leq y_0 \leq \text{top}$ and
 $\text{back} \leq z_0 \leq \text{front}?$

bounding box intersection test



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.