Visibility

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How to avoid rendering polygons

- real scenes can have hundreds of millions of polys
- view frustum culling
  - *trivial reject if all vertices "outside" with respect to any single plane of the viewing frustum*
  - *apply to groups of polygons by using bounding boxes, bounding spheres, or env grid cells*
- back-face culling
  - *cull if the eyepoint lies on the "backside" of a polygon*
  - *applies to closed solid objects (50% of polys!)*

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- visibility tables
  - *store a list of visible cells*
- horizon maps
  - *for terrain models*

- levels of detail
  - 'coarse' and 'fine' models
  - texture-mapped 'billboards'

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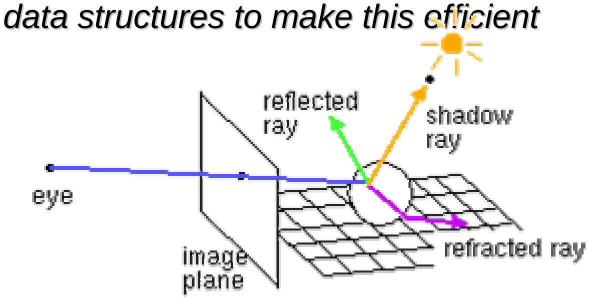
use ray casting (instead of projective rend.)

- cast a ray through each pixel
- requires efficient intersection tests
  - *walk along ray until first intersection*
  - *use data structures to make this efficient*



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Ray Tracing

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```
for each pixel on screen {
  determine ray from eye through pixel
  colour = raytrace(ray)
  set pixel to colour
}

colour raytrace(ray){
  find closest intersection of ray with an object
  reflect_colour = raytrace(reflected_ray)
  refract_colour = raytrace(refracted_ray)
  local_colour = lighting_computation()
  return k1*reflect_colour + k2*refract_colour
         + k3*local_colour
}
```

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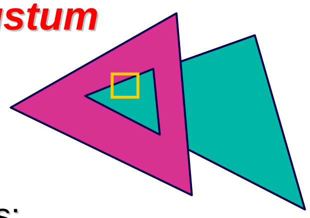
Visibility

... inside the view frustum



- image space algorithms:
  - *operate on pixels or scan-lines*
  - *visibility resolved to the precision of the display*
  - *e.g.: Z-buffer*
- object space algorithms
  - *explicitly compute visible portions of polygons*
  - *painter's algorithm: depth-sorting, BSP trees*

Z-buffer

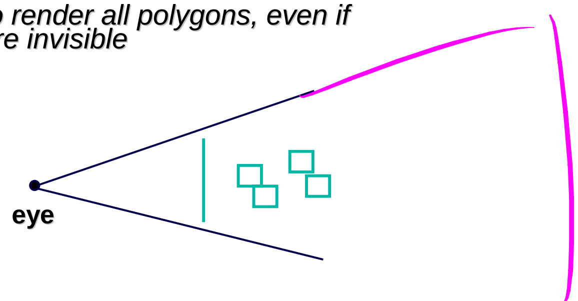
store (r,g,b,z) for each pixel

- typically 8+8+8+24 bits, can be more

```
for all i,j {
 Depth[i,j] = MAX_DEPTH
 Image[i,j] = BACKGROUND_COLOUR
}
for all polygons P {
  project vertices into screen-space, i.e., DCS
  for all pixels in P {
    if (Z_pixel < Depth[i,j]) {      or <=
      Image[i,j] = C_pixel
      Depth[i,j] = Z_pixel
    }
  }
}
```


Z-buffer

- hardware support in graphics cards
- poor for high-depth-complexity scenes
  - *need to render all polygons, even if most are invisible*



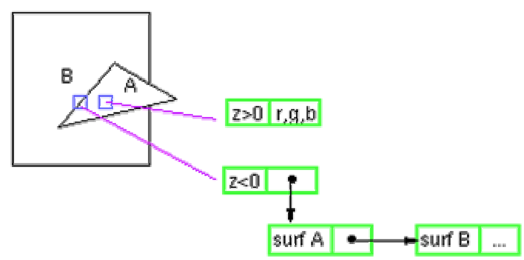
eye

- "jaggies": pixel staircase along edges

aliasing

The A-Buffer

- antialiased, area-averaged accumulation buffer
  - *z-buffer: one visible surface per pixel*
  - *A-buffer: linked list of surfaces*



- data for each surface includes
  - *RGB, Z, area-coverage percentage, ...*

Painter's Algorithm

- scan-convert polygons from back to front
  - but how to sort?

BSP trees

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Binary Space Partitions

- object-space method
- produces a back-to-front ordering
- build the BSP tree once
- traverse the BSP in a view-dependent fashion

BSP trees (example)

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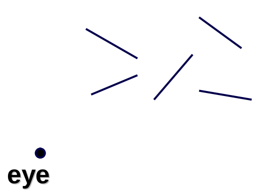
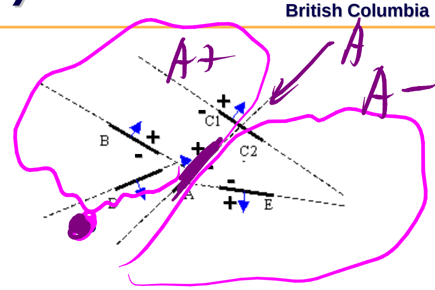
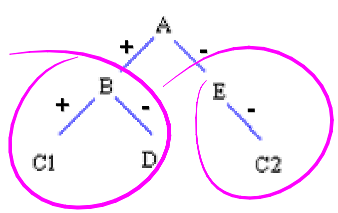




(A-)A(A+)
(E-)E(E+) A(B+)B(B-)
C2 E A C1 B D



Building a BSP tree

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```
BSPtree *BSPmaketree(polygon list) {
  choose a polygon as the tree root
  for all other polygons {
    if polygon is in front, add to front list
    if polygon is behind, add to behind list
    else split polygon and add one part to each list
  }
  BSPtree = BSPcombinetree(BSPmaketree(front list),
            root, BSPmaketree(behind list) )
}
```

Using a BSP tree

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producing a back-to-front ordering

```
DrawTree(BSPtree) {
  if (eye is in front of root) {
    DrawTree(BSPtree->behind)
    DrawPoly(BSPtree->root)
    DrawPoly(BSPtree->front)
  } else {
    DrawTree(BSPtree->front)
    DrawPoly(BSPtree->root)
    DrawTree(BSPtree->behind)
  }
}
```