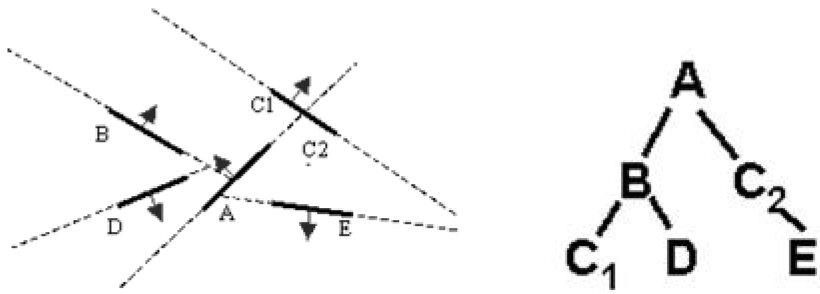
CSC418 Computer Graphics

- **BSP tree**
- **Z-Buffer**
- **A-buffer**
- **Scanline**

Binary Space Partition (BSP) Trees

- Used in visibility calculations
- Building the BSP tree (2D)
  – Start with polygons and label all edges
  – Deal with one edge at a time
  – Extend each edge so that it splits the plane in two, it's normal points in the "outside" direction
  – Place first edge in tree as root
  – Add subsequent edges based on whether they are inside or outside of edges already in the tree. Inside edges go to the right, outside to the left. (opposite of Hill)
  – Edges that span the extension of an edge that is already in the tree are split in two and both are added to the tree.
  – An example should help….

BSP tree

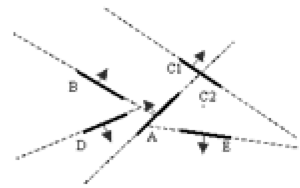


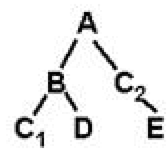
Using BSP trees

- Use BSP trees to draw faces in the right order
- Building tree does not depend on eye location
- Drawing depends on eye location
- Algorithm intuition:
- Consider any face F in the tree
  - If eye is on outside of F, must draw faces inside of F first, then F, then outside faces. Why?
    - Want F to only obscure faces it is in front of
  - If eye is on the inside of F, must draw faces outside of F first, then F (if we draw it), than inside edges
- This forms a recursive algorithm

BSP Drawing Algorithm

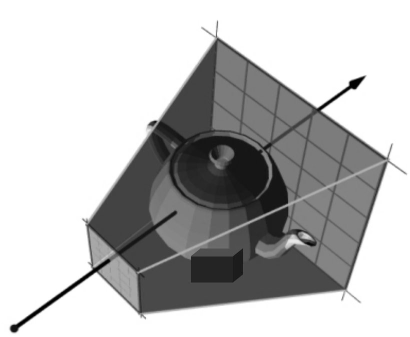
```
DrawTree(BSPtree)
{
    if (eye is in front of root)
    {
        DrawTree(BSPtree->behind)
        DrawPoly(BSPtree->root)
        DrawTree(BSPtree->front)
    } else {
        DrawTree(BSPtree->front)
        DrawPoly(BSPtree->root)
        DrawTree(BSPtree->behind)
    }
}
```





Visibility Problem

- **Z-Buffer**
- **Scanline**



Z-Buffer

- Scanline algorithm
- Z-buffer algorithm:
  1. Store background colour in buffer
  2. For each polygon, scan convert and …
  3. For each pixel
     - Determine if z-value (depth) is less than stored z-value
     - If so, swap the new colour with the stored colour

Calculating Z

- Start with the equation of a line

  $0 = A x + B y + C z + D$
- Solve for Z

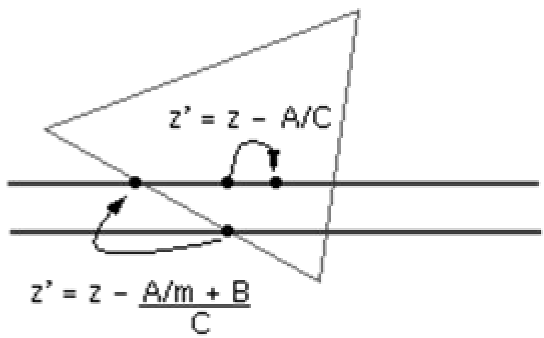
  $Z = (-A x - B y - D) / C$
- Moving along a scanline, so want z at next value of x

  $Z' = (-A (x+1) - b y - D) / C$

  $Z' = z - A/C$

Calculating Z

- For moving between scanlines, know
  $x' = x + 1 / m$
- The new left edge of the polygon is $(x+1/m, y+1)$, giving
  $z' = z - (A/m + B)/C$

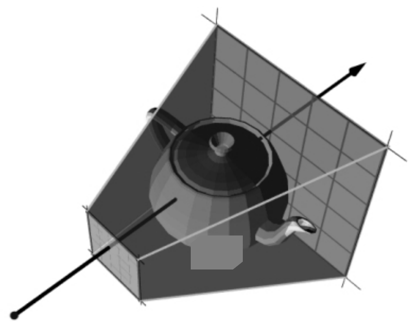


Z-Buffer Pros and Cons

- Needs large memory to keep Z values
- Can be implemented in hardware
- Can do infinite number of primitives.
- Handles cyclic and penetrating polygons.
- Handles polygon stream in any order throwing away polygons once processed

A-Buffer

- **A-buffer**

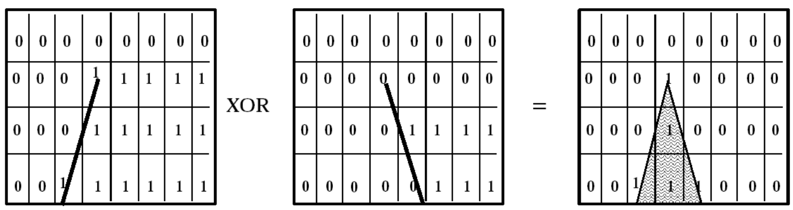


A-Buffer

- Z-Buffer with anti-aliasing
  - (much more on anti-aliasing later in the course)
- Anti-aliased, area averaged accumulation buffer
- Discrete approximation to a box filter
- Basically, an efficient approach to super sampling
- For each pixel, build a pixel mask (say an 8x8 grid) to represent all the fragments that intersect with that pixel
- Determine which polygon fragments are visible in the mask
- Average colour based on visible area and store result as pixel colour
- Efficient because it uses logical bitwise operators

A-Buffer: Building Pixel Mask

- Build a mask for each polygon fragment that lies below the pixel
- Store 1’s to the right of fragment edge
- Use XOR to combine edges to make mask

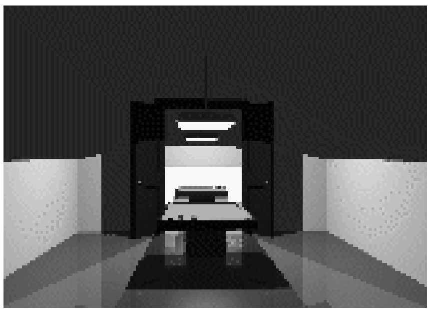


A-Buffer: Building Final Mask

- Once all the masks have been built, must build a composite mask that indicates which portion of each fragment is visible
- Start with an empty mask, add closest fragment to mask
- Traverse fragments in z-order from close to far
- With each fragment, fill areas of the mask that contain the fragment and have not been filled by closer fragments
- Continue until mask is full or all fragments have been used
- Calculate pixel colour from mask:

- Can be implemented using efficient bit-wise operations
- Can be used for transparency as well

Illumination




Illumination

- **Coming soon!**