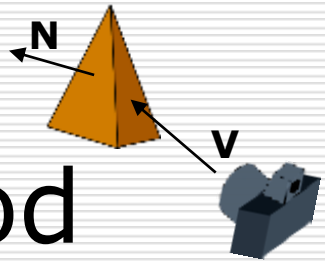
Computer Graphics (L12)
EG678EX

Visible Surface Detection

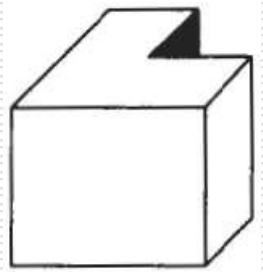
Visible Surface Detection

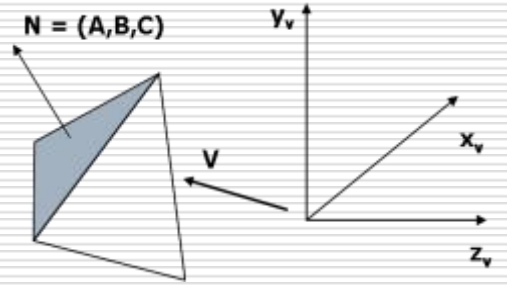
- Two approaches
  - Depends upon object definition or projected image
    - Object-space
      - Compares objects and parts of objects to each other within the scene
    - Image-space
      - Visibility is decided point by point at each pixel position on projected plane



Back Face Detection Method

- Fast and simple object-space method
- Based on "inside" or "outside" test
- Test whether view point is inside or outside the polygon surface
  - Tested by the inequality: Ax + By + Cz + D = 0
    - If view point is outside the surface → visible
    - If inside → back face
  - The test could be simplified by considering normal vector **N** = (A,B,C) to polygon surface and Vector **V** in viewing direction as:
    the polygon is back face if: **V.N**>0
- If object description is converted to viewing co-ordinates then, **V** is along z_v axis i.e **V** = $(0,0,V_z)$, then:
  V.N = V_zC
  i.e V.N > 0 → V_zC
  So we need to consider only sign of C
- For right handed viewing system with viewing direction along negative z_v axis, c<0 → back face
- Convex polyhedron?→ no problem because either completely visible or completely hidden
- Concave polyhedron?→ some problem; needs additional faces
- More than one objects? in scene → problem
- Eliminates about half of the polygon surface in a scene from further visibility tests





What if C = 0 ??
• Grazing Viewing i.e viewing direction is perpendicular to surface normal→ also back face

So, back face if C≤0

Depth Buffer (z-Buffer) method

- Image-space method
- Surface depth is compared at each pixel position on the projection plane
- Usually applied to scene containing only polygon surfaces; but possible to apply for non-planar surfaces
- For each pixel position (x,y) on projection plane, object depths can be compared by comparing z-values as each (x,y,z) position on a polygon surface corresponds to the orthographic projection point (x,y) on projection plane
- Two buffers required
  - Depth buffer: to store depth value for each position
  - Refresh buffer: to store intensity values of each position
- Drawback: Deals only with opaque surface but not with transparent surface

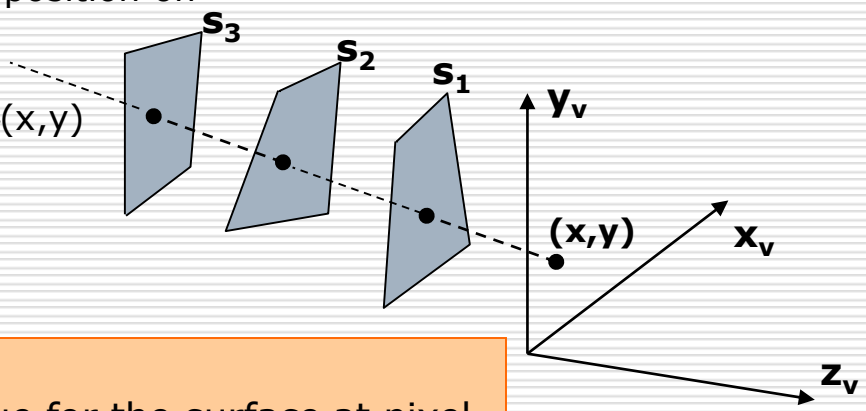
Depth Buffer (contd…)

1. Initialize the depth buffer and refresh buffer so that for all buffer positions (x,y),

   depth(x,y) = 0, refresh(x,y) = $I_{backgrnd}$

2. For each position on each polygon surface, compare depth values to previously stored values in the depth buffer to determine visibility
   - Calculate the depth z for each (x,y) position on the polygon
   - If z>depth(x,y), then set

     depth(x,y)=z, refresh(x,y)=I_{surf}(x,y)



$I_{backgrnd}$ = background intensity
I_{surf}(x,y) = projected intensity value for the surface at pixel position (x,y)

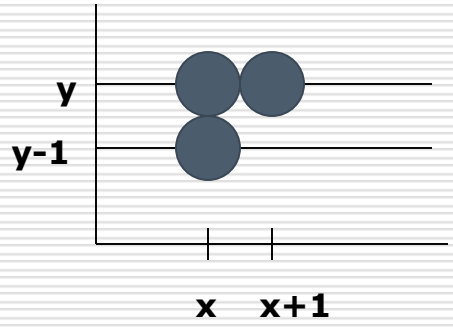
Depth Buffer (depth calculation)

- From plane equation, depth is

$$z = \frac{-Ax - By - D}{C}$$

- For the next adjacent pixel in a scan line, depth is

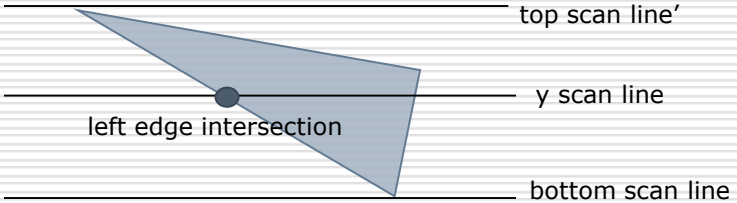
$$z' = \frac{-A(x+1) - By - D}{C} \quad \text{or} \quad z' = z - \frac{A}{C}$$



- Determine minimum and maximum y-coordinates for each polygon
- Start from top scan line to bottom scan line
- Starting from top vertex, calculate x position down the left edge of the polygon recursively as

  $x' = x - 1/m$

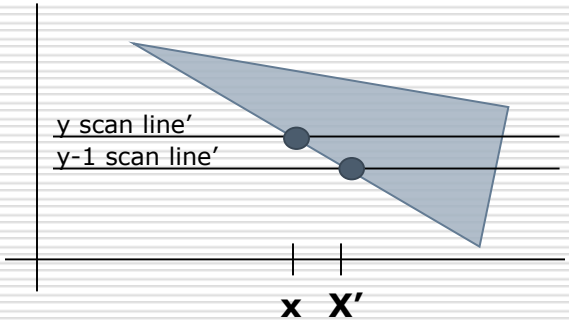
  $m(x'-x)=y'-y=-1$



- Thus depth value for the next pixel in left edge is obtained as

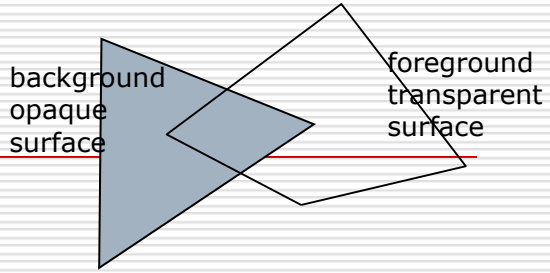
$$z' = z + \frac{\frac{A}{m} + B}{C}$$

  put x' = x-1/m and y' = y-1

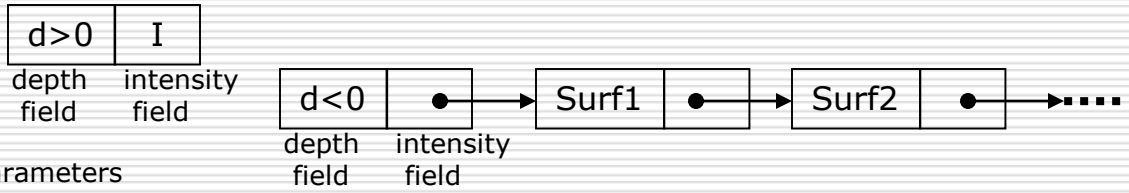


- For vertical edge m = infinity, so: $z' = z + \frac{B}{C}$

A-Buffer Method



- Extension of depth buffer method
- Antialiased, area-average, accumulation-buffer
- The depth buffer is expanded so that each position in the buffer can reference a linked list of surfaces thus enabling more than one surface intensity consideration
- The object boundary could be antialiased
- Each pixel position in the A-Buffer has two fields
  - Depth Field → stores a positive or negative real number
    - Positive→ single surface contributes to pixel intensity
    - Negative → multiple surfaces contribute to pixel intensity
  - Intensity Field → stores surface-intensity information or a pointer value
    - Surface intensity if single surface → stores the RGB components of the surface color at that point and percent of pixel coverage
    - Pointer value if multiple surfaces
  - in case of surface linked list, the data for each surface in the linked list includes
    - RGB intensity
    - Opacity parameter
    - Depth
    - Percent of area coverage
    - Surface identifier
    - Other surface-rendering parameters
    - Pointer to next surface



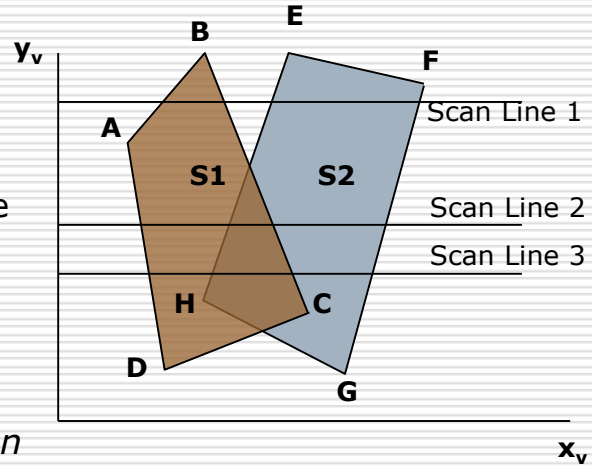
  - Scanlines are processed to determine surface overlaps of pixels across the individual scanlines.
  - Surfaces are subdivided into a polygon mesh and clipped against the pixel boundaries
  - The opacity factors and percent of surface overlaps are used to determine the pixel intensity as an average of the contribution from the overlapping surfaces

Scan-Line Method

- Extension of scanline algorithm for filling polygon interiors
- Instead of filling just one surface, we deal with multiple surfaces
- Construct edge tables and polygon tables
  - Edge table contains → endpoints of each edge in the scene, inverse slope of each line and pointers to the polygon table to identify its corresponding surface
  - Polygon table contains → plane equation coefficients, surface intensity, pointers to the edge table (optional)
- Setup an active list (why active ??) of edges for those edges which cross the current scan line
  - The edges are sorted in order of increasing x
- Define flags for each surface to indicate whether a position is inside or outside the surface
  - At leftmost boundary of surface flag == *on* and at rightmost boundary flag == *off*

Scan-Line Method (contd…)

- For scan line 1
  - The active edge list contains edges AB,BC,EH, FG
  - Between edges AB and BC, only *flags for s1 == on* and between edges EH and FG, only *flags for s2==on*
    - no depth calculation needed and corresponding surface intensities are entered in refresh buffer
- For scan line 2
  - The active edge list contains edges AD,EH,BC and FG
  - Between edges AD and EH, only the *flag for surface s1 == on*
  - Between edges EH and BC *flags for both surfaces == on*
    - Depth calculation (using plane coefficients) is needed.
    - In this example depth for s1 is less than for s2, so intensities for surface s1 are loaded into the refresh buffer until boundary BC is encountered
  - Between edges BC and FG *flag for s1 == off* and *flag for s2 == on*
    - Intensities for s2 are loaded on refresh buffer
- For scan line 3
  - Same **coherent** property as scan line 2 as noticed from active list, so no depth calculation needed between edges BC and EH



Scan-Line Method (contd…)

- Problem: Dealing with **cut through** surfaces and **cyclic overlap** is problematic when used coherent properties
  - Solution: Divide the surface to eliminate the overlap or cut through