

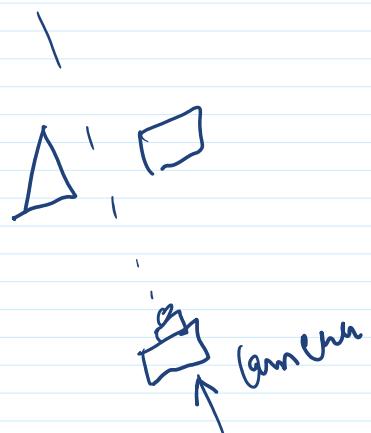
## 22. Visible Surface Detection (VSD)

18 March 2024 19:29

Source: Computer Graphics by Donald Hearn and M. Pauline Baker

(hidden surface elimination methods)

Given a set of 3D surfaces to be projected onto a 2D screen, obtain the nearest surface corresponding to any point on the screen.



Types of VSD algorithms

Object-space methods

Image-space methods

- ⇒ Compares objects and parts of objects to each other to determine which surface should be labelled as visible
- ⇒ Visibility is decided point by point at each pixel position on the projection plane.

Sorting properties :-

⇒ Used for depth comparisons by ordering the individual surfaces in a scene according to their distance from the view plane.

Coherence properties :-

⇒ degree to which part of an environment exhibit local similarities.

Kinds of coherence :-

① Object coherence :-

If one object is entirely separate from another, comparisons may need to be done only between the two objects, and not between their component faces or edges.

② Face coherence :-

Smooth variations across a face, computations incrementally modified and applied to adjacent parts.

### ③ Edge coherence :-

An edge may change visibility if it crosses behind a visible edge.

### ④ Implied edge coherence :-

If one planar face penetrates another, their line of intersection (implied edge) can be determined from two points of intersection.

### ⑤ Scanline coherence :

The set of visible object spans determined for one scan line of an image typically differs only a little from the set on the previous line.

### ⑥ Area coherence :-

A group of adjacent pixels is often covered by the same visible face.

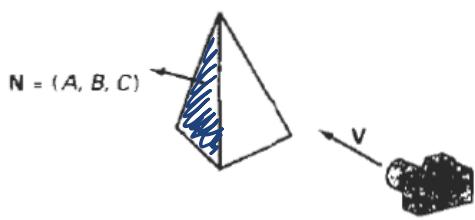
### ⑦ Depth coherence :-

Using difference equation to estimate depths of nearby points on the same surface.

### ⑧ Frame coherence :-

Pictures of the same environment at two successive points in the time are similar.

## Back-face detection :-

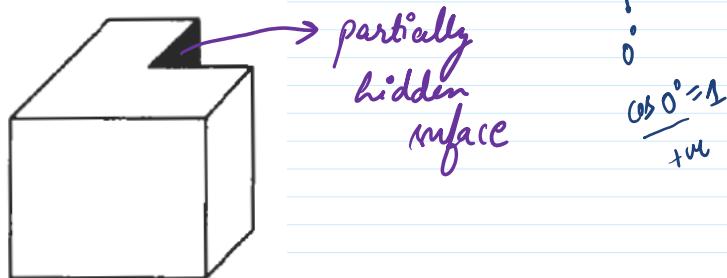


Let  $N$  is the normal vector to a polygon surface, which has cartesian components  $(A, B, C)$ .

Let  $V$  is a vector in the viewing direction from the camera position, then this polygon is a back face if

$$V \cdot N > 0 \text{ then back face.}$$

A conservative algorithm,



In general, back-face removal can be effected to eliminate half of the polygon surfaces in a scene from further visibility tests.

Depth-buffer / Z-buffer method :-

⇒ Object depth is measured along the z-axis of a viewing system.

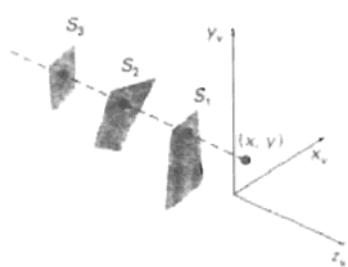


Figure 13-4  
At view-plane position  $(x_v, y_v)$ , surface  $S_1$  has the smallest depth from the view plane and so is visible at that position.

$\Rightarrow$  Compares surface depths at each pixel position on the projection plane.

### ALGORITHM :-

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

$$\text{depth}(x, y) = 0 \quad \text{refresh}(x, y) = I_{\text{background}}$$

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  $z < \text{depth}(x, y)$ , then set

$$\text{depth}(x, y) = z, \quad \text{refresh}(x, y) = I_{\text{surf}}(x, y)$$

$I_{\text{background}}$  = value of background intensity

$I_{\text{surf}}(x, y)$  = projected intensity value for the surface at  $(x, y)$ .

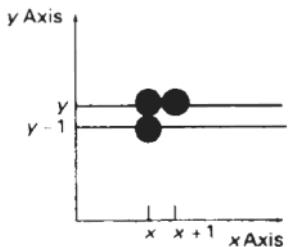
After all surfaces have been processed, depth buffer contains depth values for the visible surfaces and the refresh buffer contains the corresponding intensity values for those surfaces.

Equation of surface:-

$$Ax + By + Cz + D = 0$$

$\Rightarrow$  Depth value for a surface position  $(x, y)$ ,

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



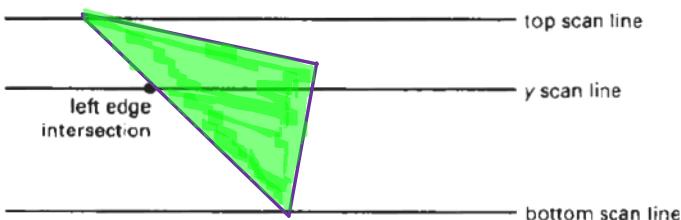
**Figure 13-5**  
From position  $(x, y)$  on a scan line, the next position across the line has coordinates  $(x + 1, y)$ , and the position immediately below on the next line has coordinates  $(x, y - 1)$ .

⇒ Depth  $z'$  of the next position  $(x+1, y)$ ,

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

or 
$$\boxed{z' = z - \frac{A}{C}} \quad \text{--- (1)}$$

⇒ The ratio  $-A/C$  is constant for each surface, so succeeding depth values across a scan line are obtained from preceding values with a single addition.



**Figure 13-6**  
Scan lines intersecting a polygon surface.

⇒ Calculation is done along each scan line at each successive position using (1).

⇒ For successive scan lines,

$$z' = \frac{-Ax' - B(y-1) - D}{C}$$

Let  $m$  be the slope of the edge,

$$x' = x - \frac{1}{m}$$

$$z' = \frac{-A(x - \frac{1}{m}) - By - D}{C}$$

$$z' = \frac{-Ax - By - D}{C} + \frac{A/m + B}{C}$$

$$\boxed{z' = z + \frac{A/m + B}{C}} \quad \text{--- (2)}$$

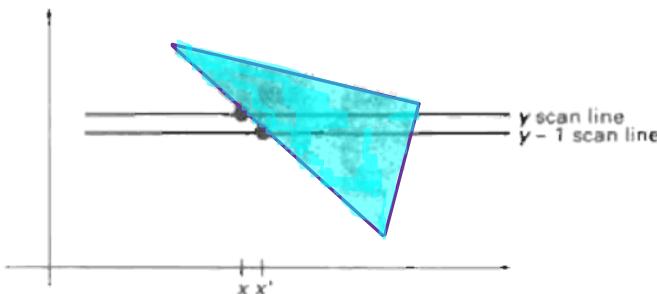


Figure 13-7

Intersection positions on successive scan lines along a left polygon edge.

Quiz :-

What kind of visible surface detection are the back-face detection and depth-buffer methods?

- A. Object-space methods
- B. Image-space methods.
- C. Object-space and Image-space, respectively.
- D. Image-space and object-space, respectively.