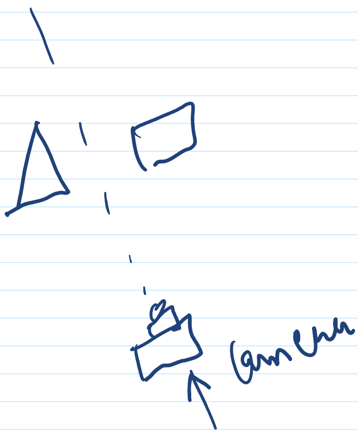
22. Visible Surface Detection

18 March 2024 19:29

(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 coherences :-

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 adjascent 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 **Scan line 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.

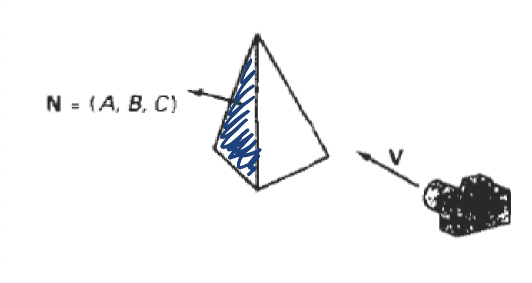
⑦ **Depth coherence:—**

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.

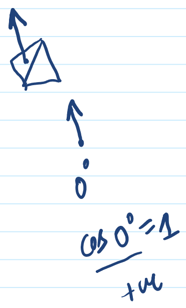
Back-face detection:—



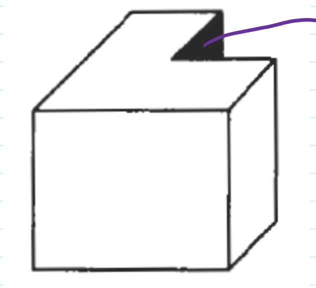
Let N is the normal vector to a polygon surface, which has cartesian components (A, B, C).

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 expected 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.

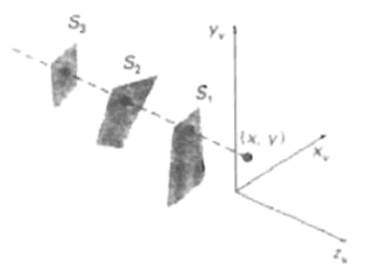


Figure 13-4
At view-plane position (x, y), surface S_1 has the smallest depth from the view plane and so is visible at that position.

⇒ 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),

$$depth(x,y) = 0 \qquad refresh(x,y) = I_{backgnd}$$

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

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

$I_{backgrd}$ = value of background intensity

$I_{surf}(x,y)$ = 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:-

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

⇒ Depth value for a surface position (x, y),

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

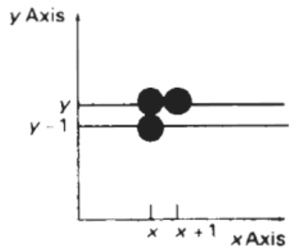


Figure 13-5
From position (x, y) on a scan line, the next position across the line has coordinates (x + 1, y), and the position immediately below on the next line has coordinates (x, y − 1).

⇒ 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.

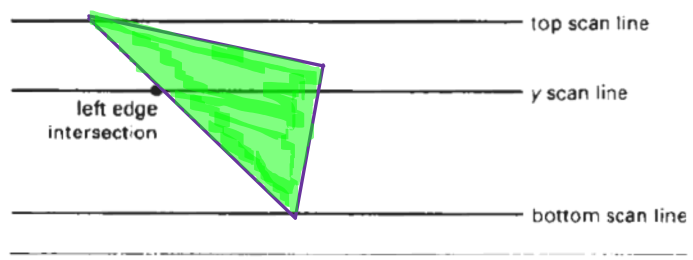


Figure 13-6
Scan lines intersecting a polygon surface.

⇒ 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,

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

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

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

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

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

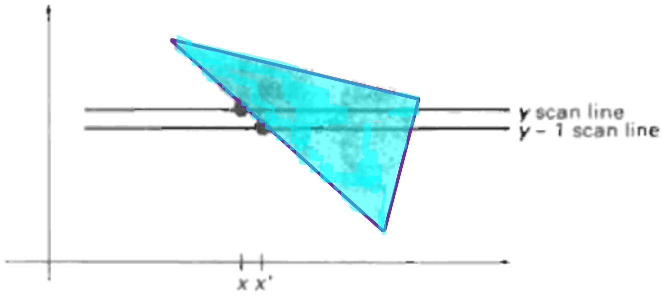


Figure 13-7
Intersection positions on successive scan lines along a left polygon edge.

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.