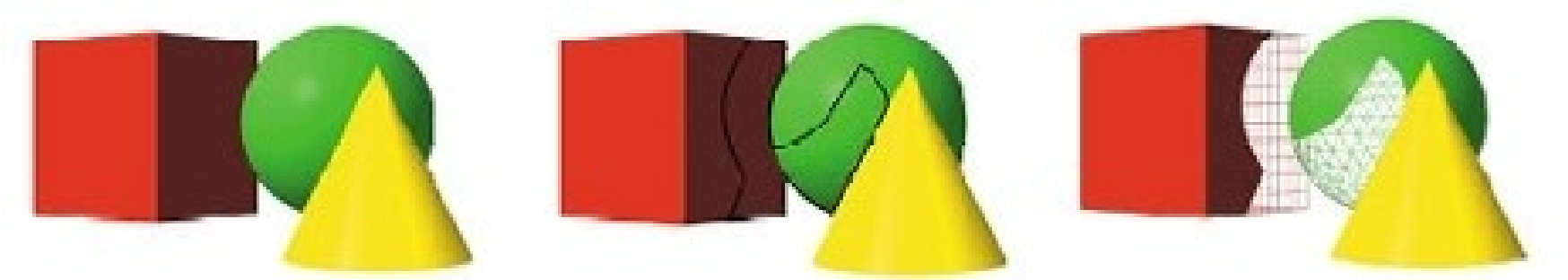
Computer Graphics : Surface Detection Methods

Contents

- Today we will start to take a look at visible surface detection techniques:
  - Why surface detection?
  - Back face detection
  - Depth-buffer method
  - A-buffer method
  - Scan-line method

Why?

- We must determine what is visible within a scene from a chosen viewing position
- For 3D worlds this is known as **visible surface detection** or **hidden surface elimination**

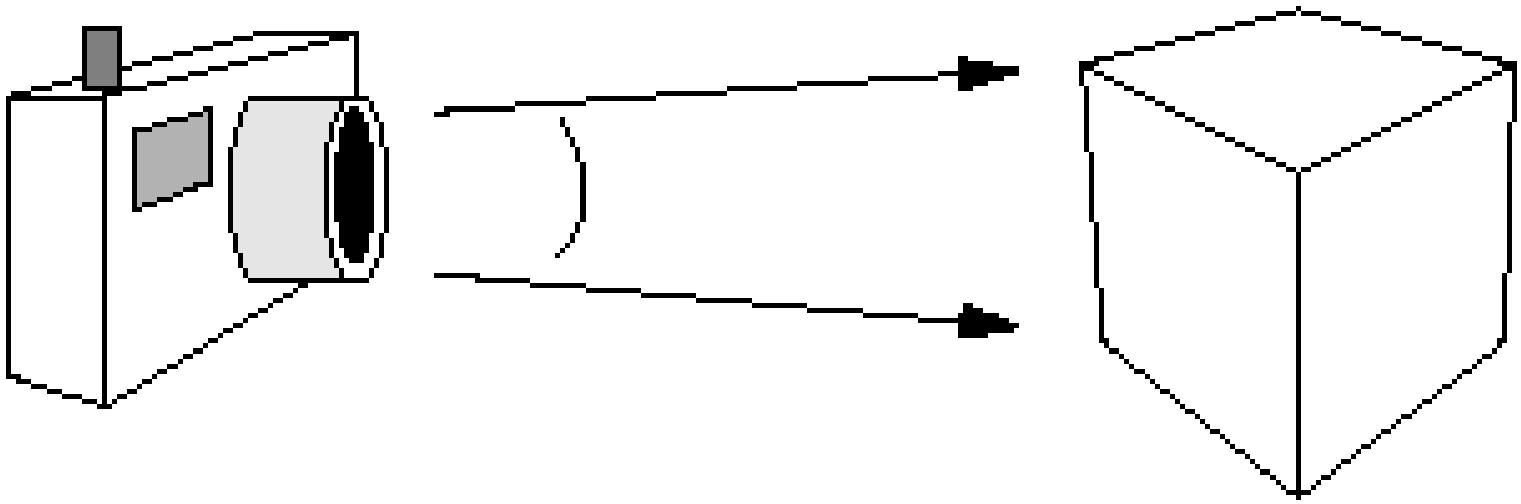


Two Main Approaches

- Visible surface detection algorithms are broadly classified as:
  - **Object Space Methods:** Compares objects and parts of objects to each other within the scene definition to determine which surfaces are visible
  - **Image Space Methods:** Visibility is decided point-by-point at each pixel position on the projection plane
- Image space methods are by far the more common

Back-Face Detection

- The simplest thing we can do is find the faces on the backs of polyhedra and discard them



Back-Face Detection (cont…)

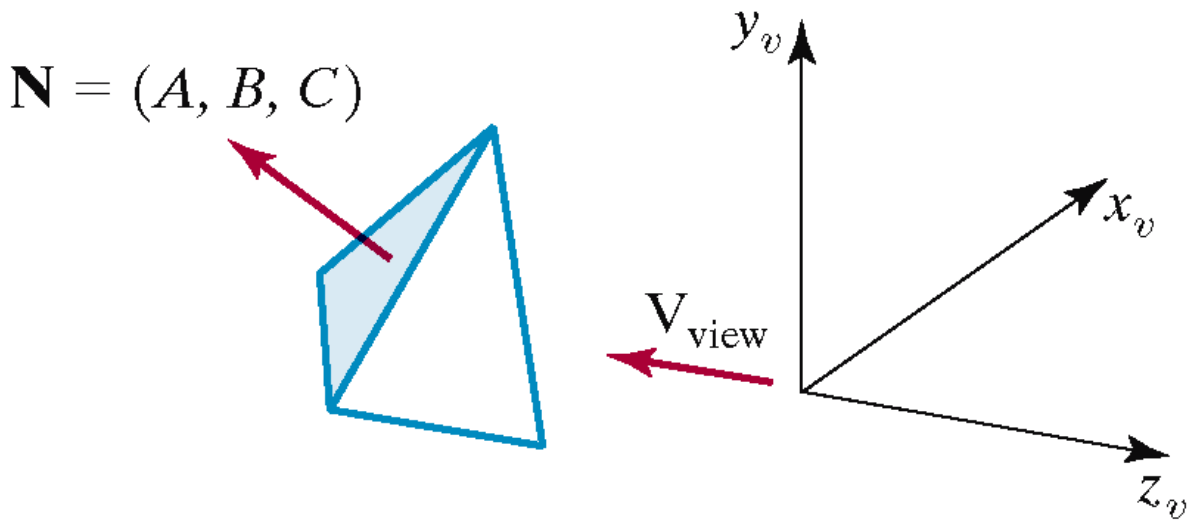
- We know from before that a point (x, y, z) is behind a polygon surface if:

$$Ax + By + Cz + D < 0$$

- where A, B, C & D are the plane parameters for the surface
- This can actually be made even easier if we organise things to suit ourselves

Back-Face Detection (cont…)

- Ensure we have a right handed system with the viewing direction along the negative z-axis
- Now we can simply say that if the z component of the polygon's normal is les be se



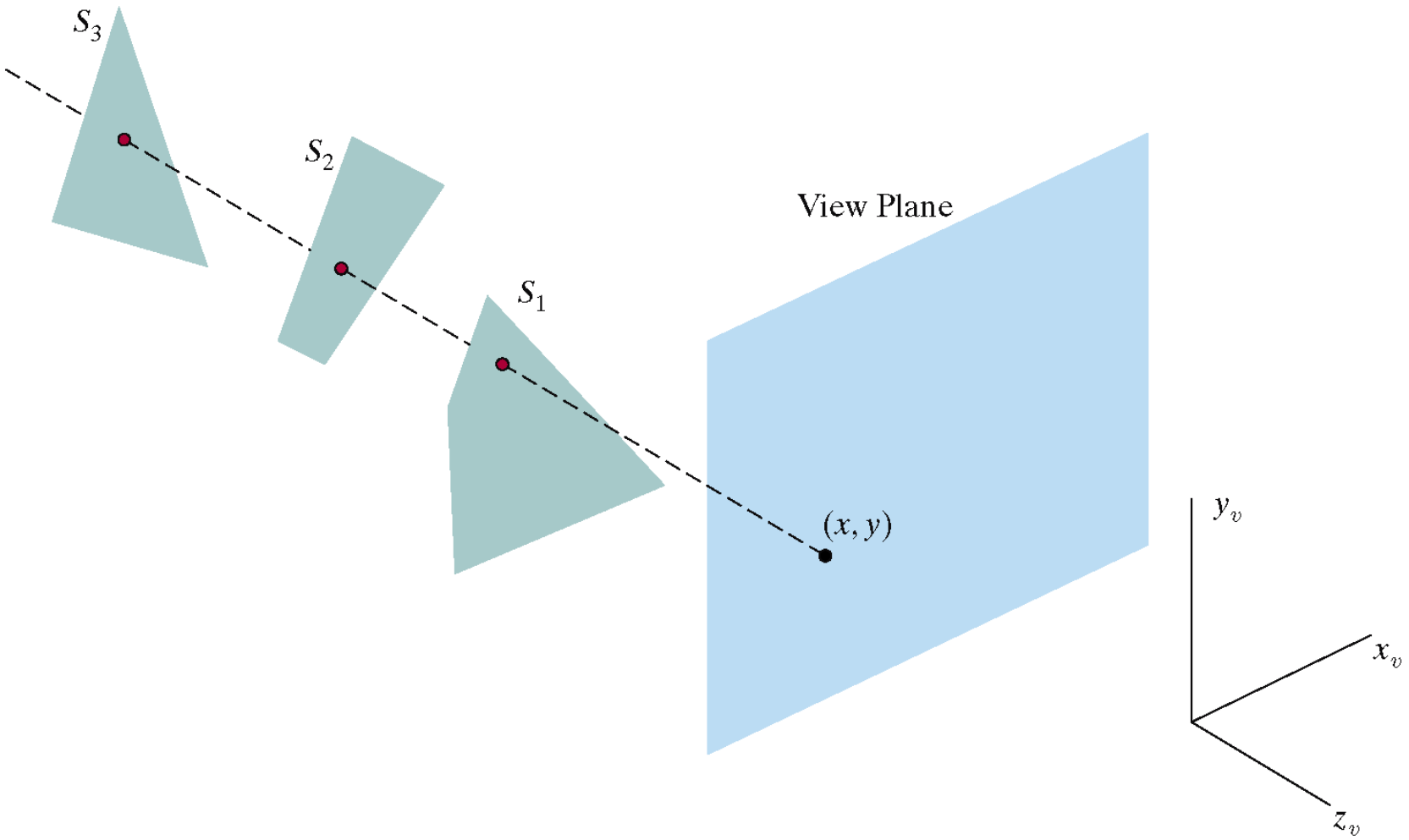
Back-Face Detection (cont…)

- In general back-face detection can be expected to eliminate about half of the polygon surfaces in a scene from further visibility tests
- More complicated surfaces though scupper us!
- We need better techniqu to handle these kind of situations

Depth-Buffer Method

- Compares surface depth values throughout a scene for each pixel position on the projection plane
- Usually applied to scenes only containing polygons
- As depth values can be computed easily, this tends to be very fast
- Also often called the z-buffer method

Depth-Buffer Method (cont.)



Images taken from Hearn & Baker, "Computer Graphics with OpenGL" (2004)

Depth-Buffer Algorithm

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

- depthBuff(x, y) = 1.0
- frameBuff(x, y) = bgColour

Depth-Buffer Algorithm (cont...)

2. Process each polygon in a scene, one at a time
   - For each projected (x, y) pixel position of a polygon, calculate the depth z (if not already known)
   - If z < depthBuff(x, y), compute the surface colour at that position and set

     depthBuff(x, y) = z

     frameBuff(x, y) = surfColour(x, y)

   After all surfaces are processed depthBuff and frameBuff will store correct values

Calculating Depth

- At any surface position the depth is calculated from the plane equation as:

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

- For any scan line adjacent x positions differ by ± 1, as do adjacent y positions

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

Iterative Calculations

- The depth-buffer algorithm proceeds by starting at the top vertex of the polygon
- Then we recursively calculate the x-coordinate values down a left edge of the polygon
- The x value for the beginning position on each scan line can be calculated from the previous one

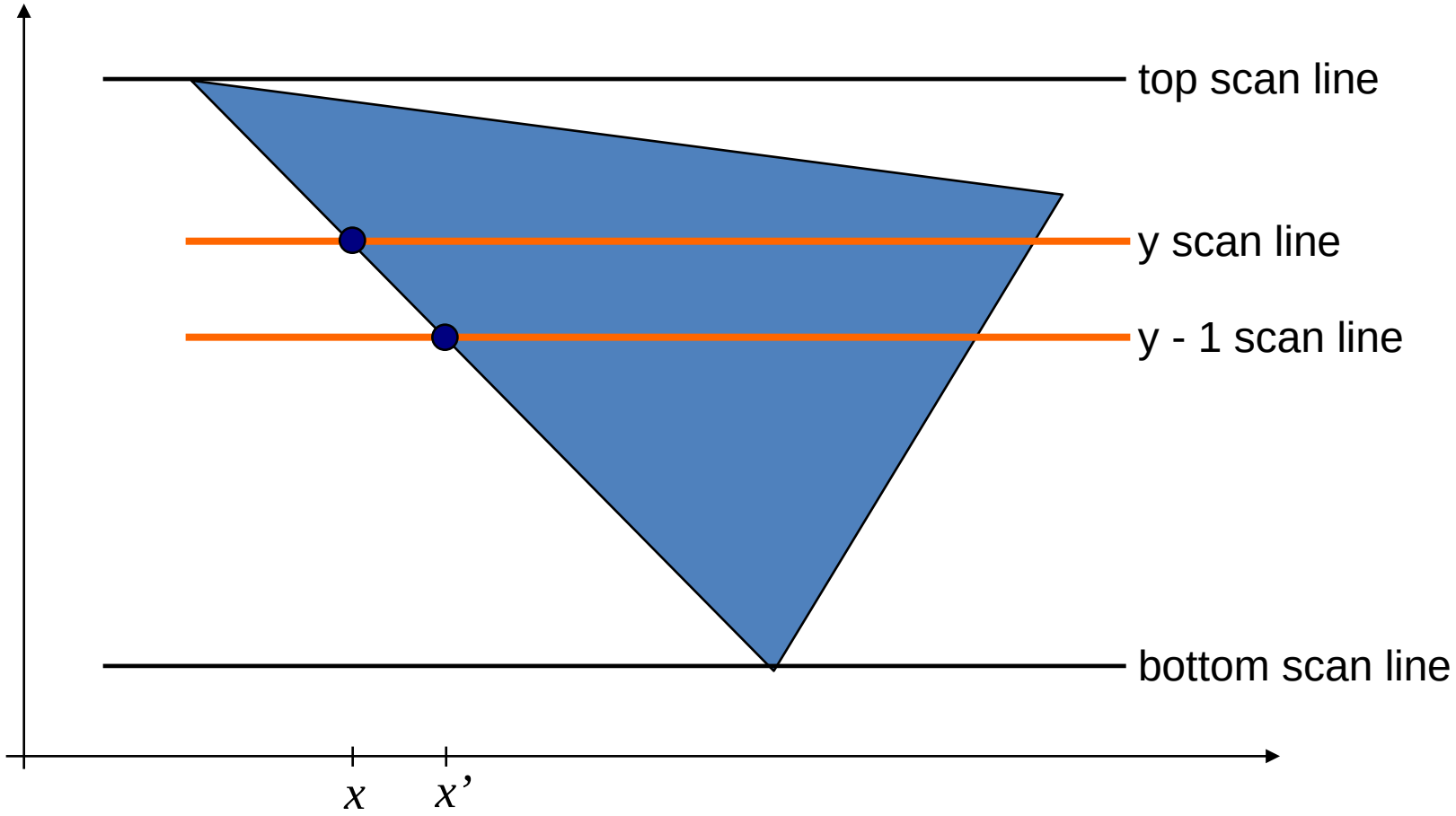
$$x' = x - \frac{1}{m}$$ where m is the slope

Iterative Calculations (cont…)

- Depth values along the edge being considered are calculated using

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

Iterative Calculations (cont…)

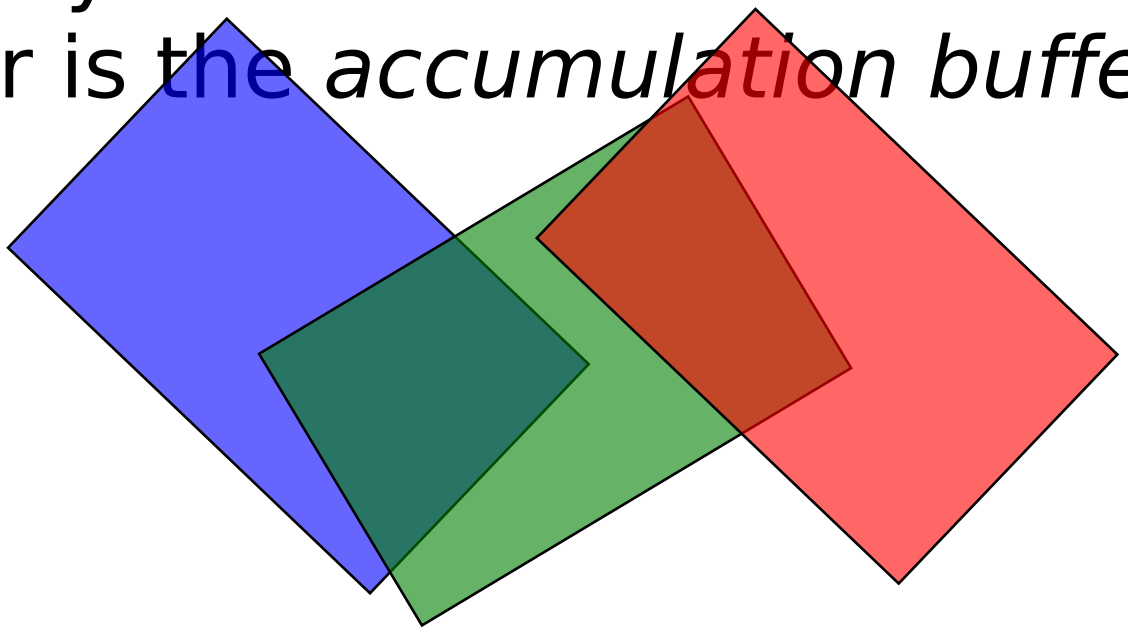


A-Buffer Method

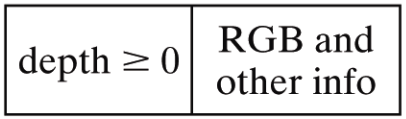
- The A-buffer method is an extension of the depth-buffer method
- The A-buffer method is visibility detection method developed at Lucasfilm Studios for the rendering system REYES (**R**enders **E**verything **Y**

A-Buffer Method (cont…)

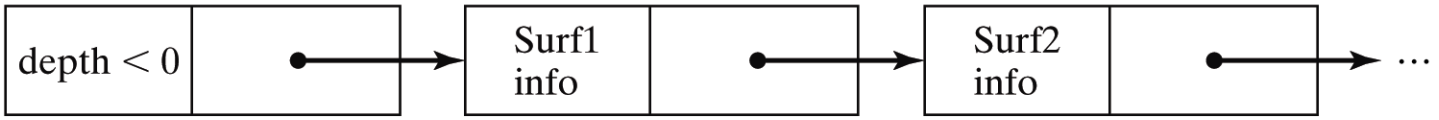
- The A-buffer expands on the depth buffer method to allow transparencies
- The key data structure in the A-buffer is the *accumulation buffer*



A-Buffer Method (cont…)



(a)



(b)

- If depth is >= 0, then the surface data field stores the depth of that pixel position as before
- If depth < 0 then the data filed stores a pointer to a linked list of surface data

A-Buffer Method (cont…)

- Surface information in the A-buffer includes:
  - RGB intensity components
  - Opacity parameter
  - Depth
  - Percent of area coverage
  - Surface identifier
  - Other surface rendering parameters
- The algorithm proceeds just like the depth buffer algorithm
- The depth and opacity values are used to determine the final colour of a pixel

Scan-Line Method

- An image space method for identifying visible surfaces
- Computes and compares depth values along the various scan-lines for a scene

Scan-Line Method (cont…)

- Two important tables are maintained:
  - The edge table
  - The surface facet table
- The edge table contains:
  - Coordinate end points of reach line in the scene
  - The inverse slope of each line
  - Pointers into the surface facet table to connect edges to surfaces

Scan-Line Method (cont…)

- The surface facet tables contains:
  - The plane coefficients
  - Surface material properties
  - Other surface data
  - Maybe pointers into the edge table

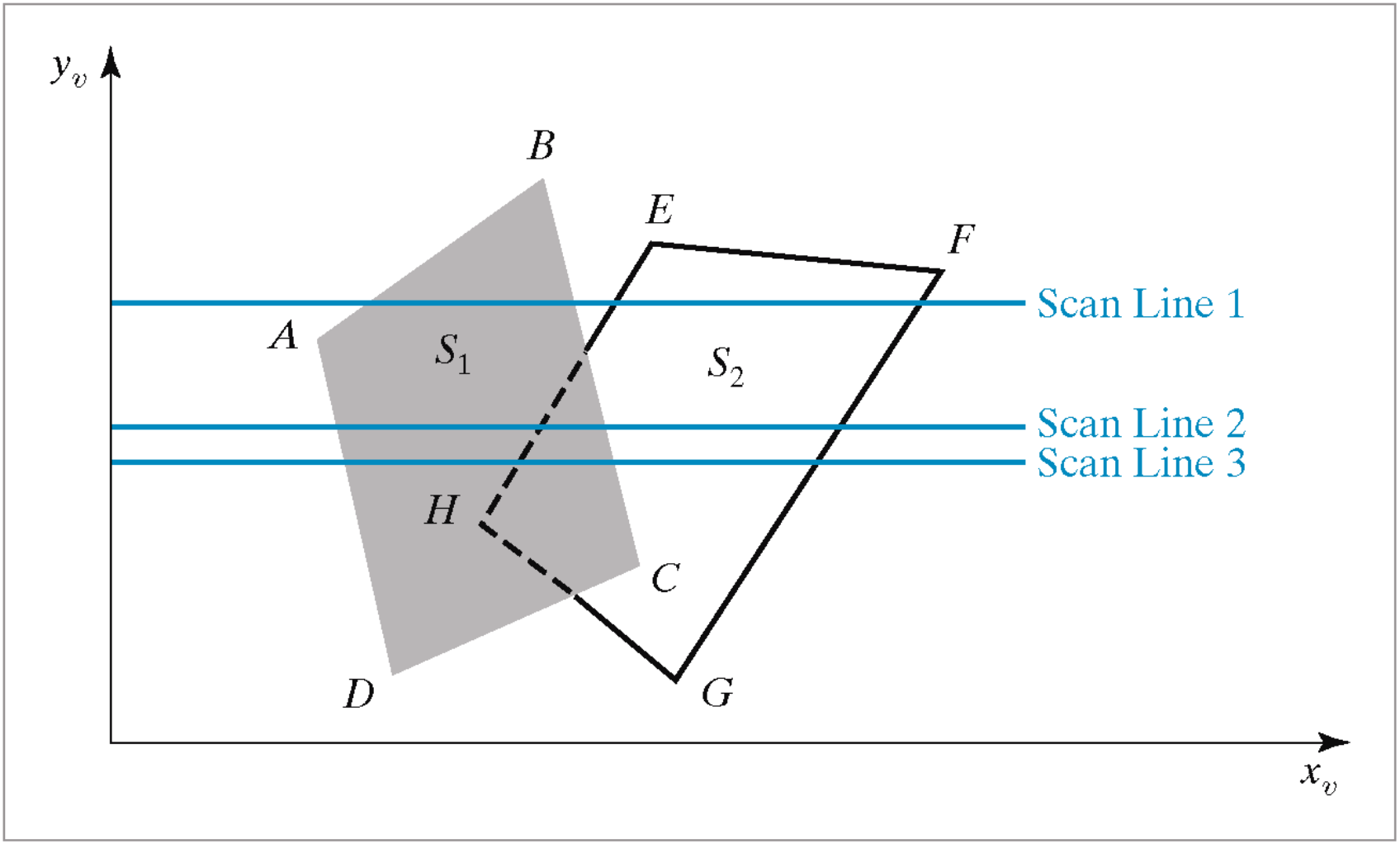
Scan-Line Method (cont…)

- To facilitate the search for surfaces crossing a given scan-line an active list of edges is formed for each scan-line as it is processed
- The active list stores only those edges that cross the scan-line in order of increasing x
- Also a flag is set for each surface to indicate whether a position along a scan-line is either inside or outside the surface

Scan-Line Method (cont…)

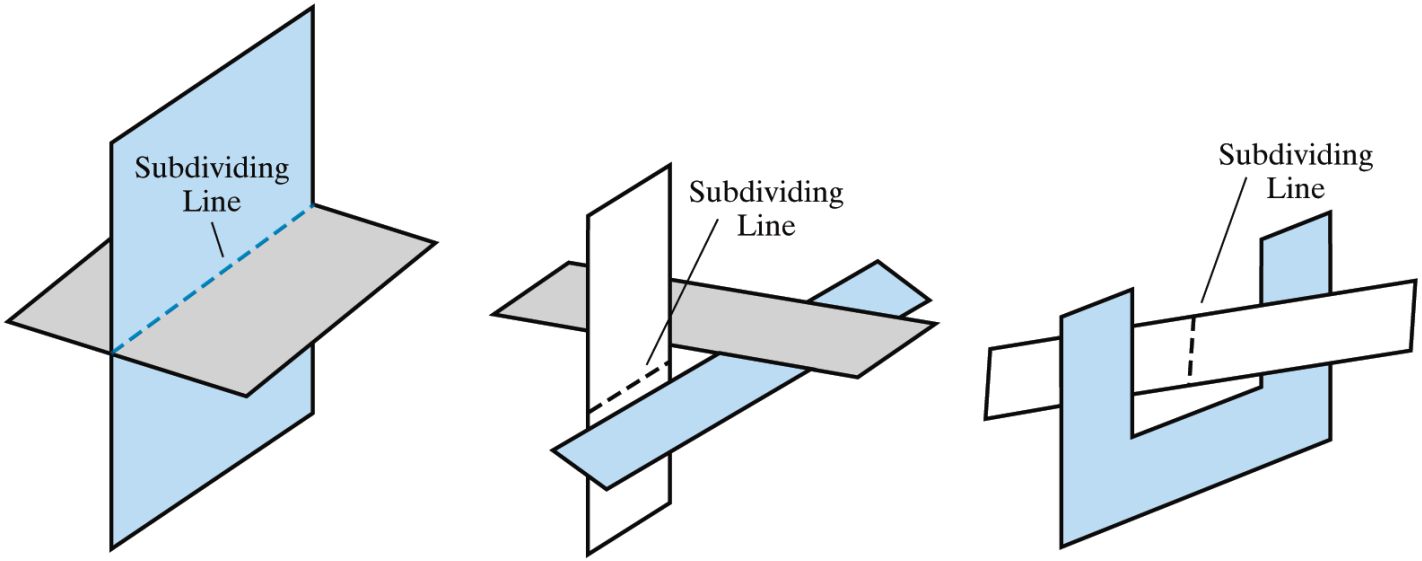
- Pixel positions across each scan-line are processed from left to right
- At the left intersection with a surface the surface flag is turned on
- At the right intersection point the flag is turned off
- We only need to perform depth calculations when more than one surface has its flag turned on at a certain scan-line position

Scan Line Method Example



Scan-Line Method Limitations

- The scan-line method runs into trouble when surfaces cut through each other or otherwise cyclically overlap
- Such surfaces need to be divided



Summary

- We need to make sure that we only draw visible surfaces when rendering scenes
- There are a number of techniques for doing this such as
  - Back face detection
  - Depth-buffer method
  - A-buffer method
  - Scan-line method
- Next time we will look at some more techniques and think about which techniques are suitable for which situations