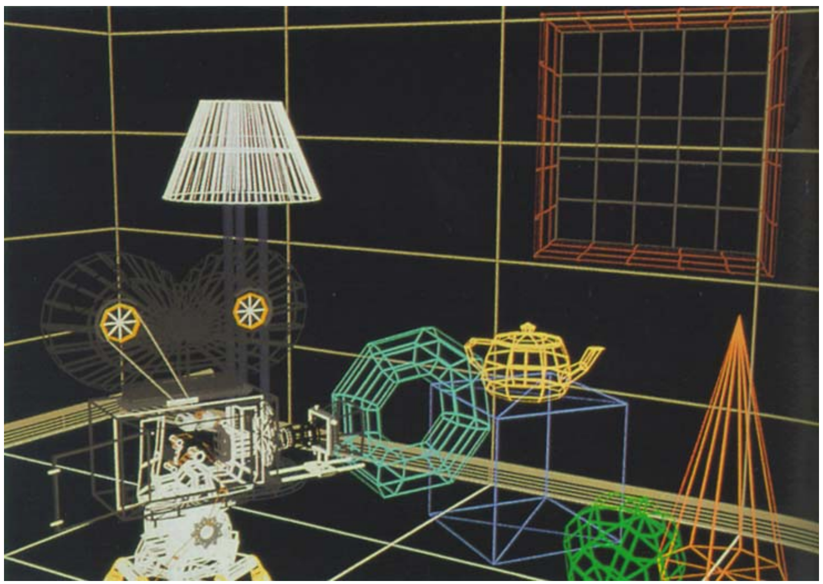
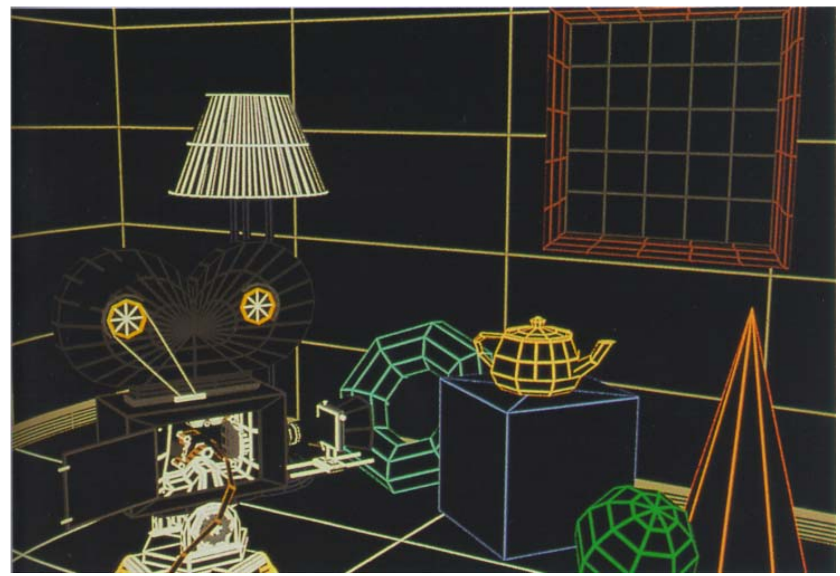
Visible Surface Determination
Part II

Foley & Van Dam, Chapter 15





Visible Surface Determination

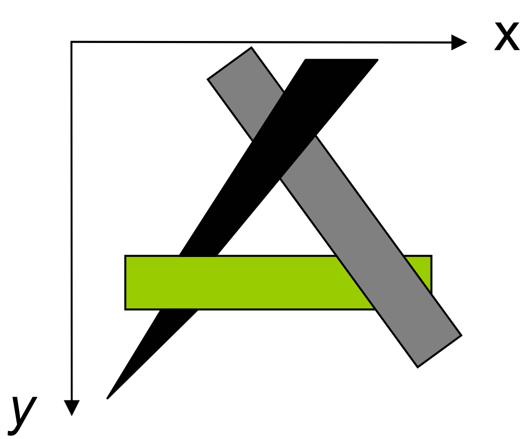
- Depth Sort (Painter Algorithm)
- Binary Space Partitioning Tree
- Area Subdivision Algorithms (Warnock’s)

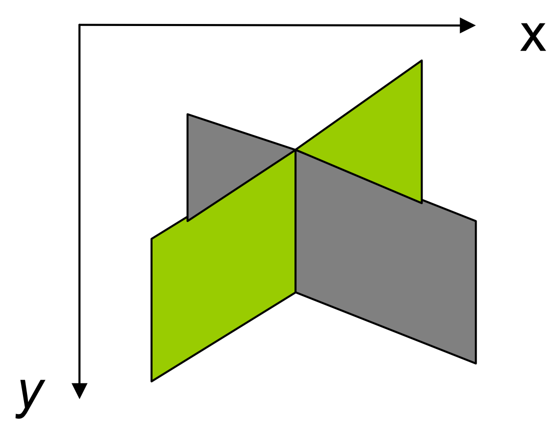
Depth Sort (Painter Algorithm)

- **Algorithm**:
  - Sort the polygons in the scene by their depth
  - Draw them back to front

- **Problem**: Unless all polygons have constant z, a strict depth ordering may not exist

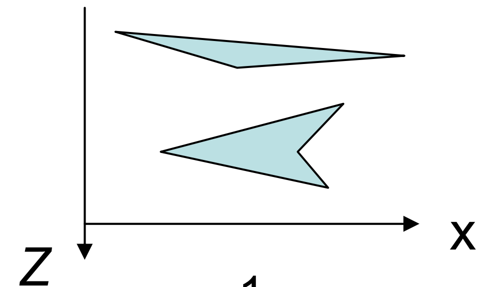
Note: Constant z case is important in VLSI design





Depth Sort (Painter Algorithm)

- **General Case**: Given two polygons P and Q, an order may be determined between them, if at least one of the following holds:
  1) z values of P and Q do not overlap
  2) The bounding rectangle in the x, y plane for P and Q do not overlap
  3) P is totally on one side of Q's plane
  4) Q is totally on one side of P's plane
  5) The bounding rectangles of Q and P do not intersect in the projection plane



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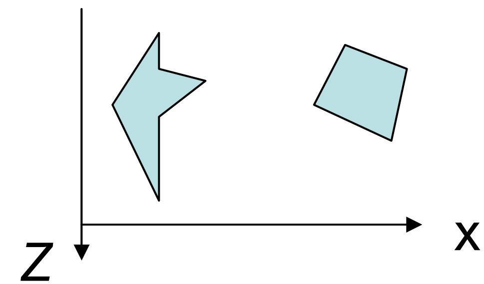

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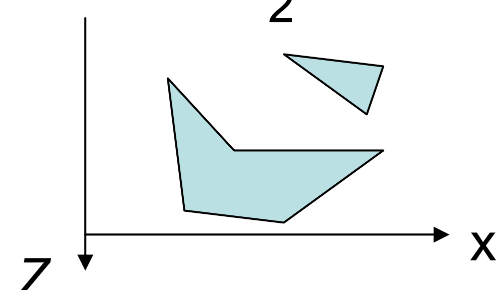
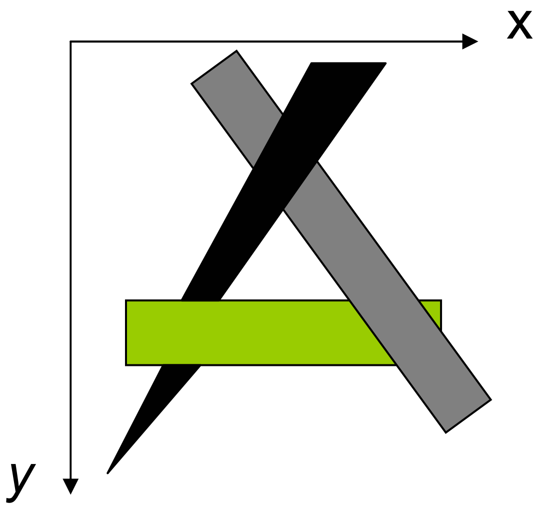
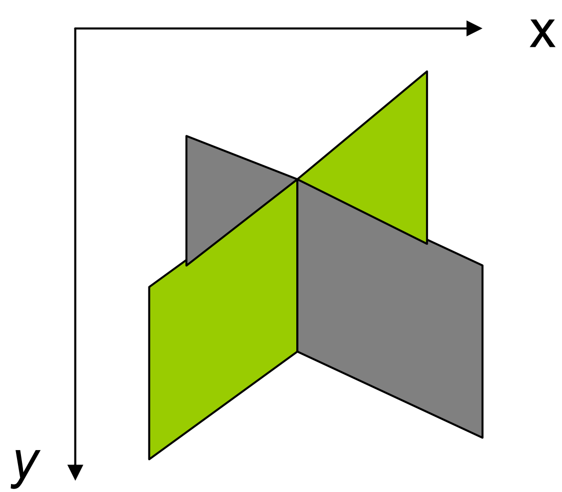


3 and 4

Depth Sort (Painter Algorithm)

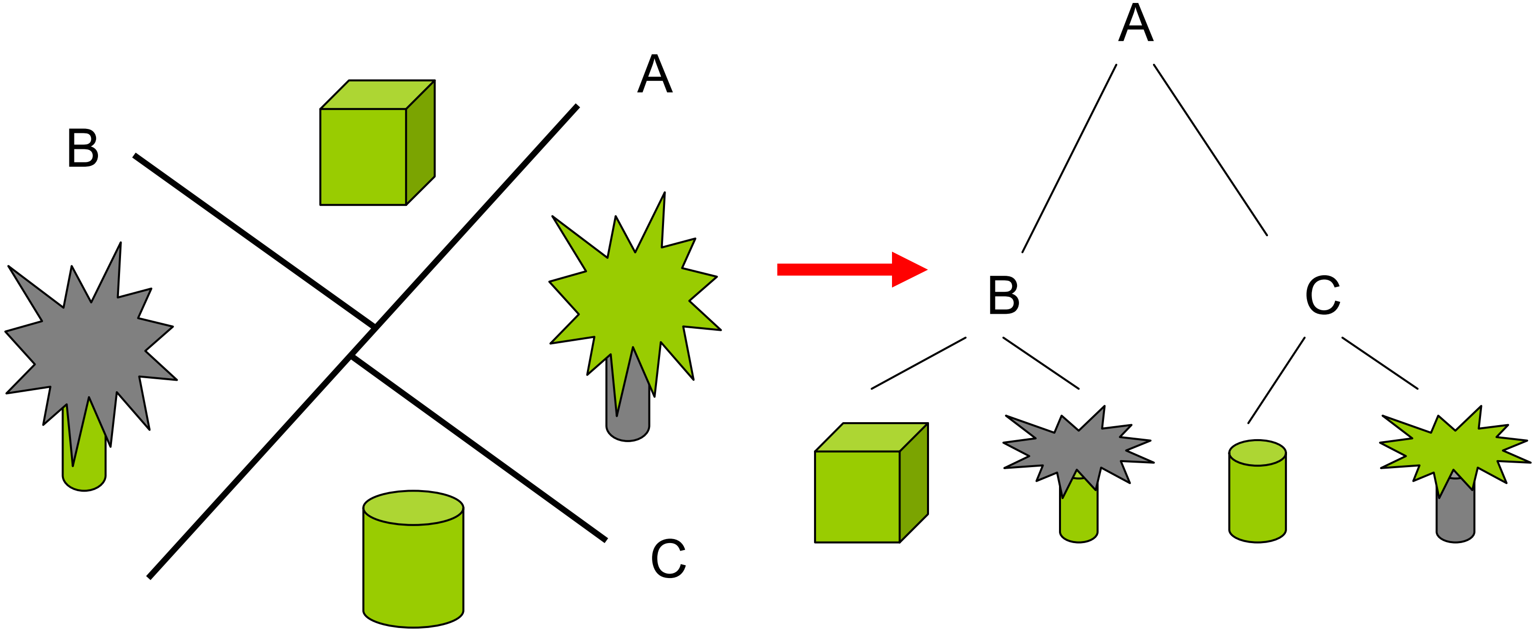
- If all the above conditions do not hold, P and Q may be split along intersection edge into two smaller polygons





Binary Space Partitioning Tree

- Interior nodes correspond to partitioning planes
- Leaf nodes correspond to convex regions of space



Binary Space Partitioning Tree

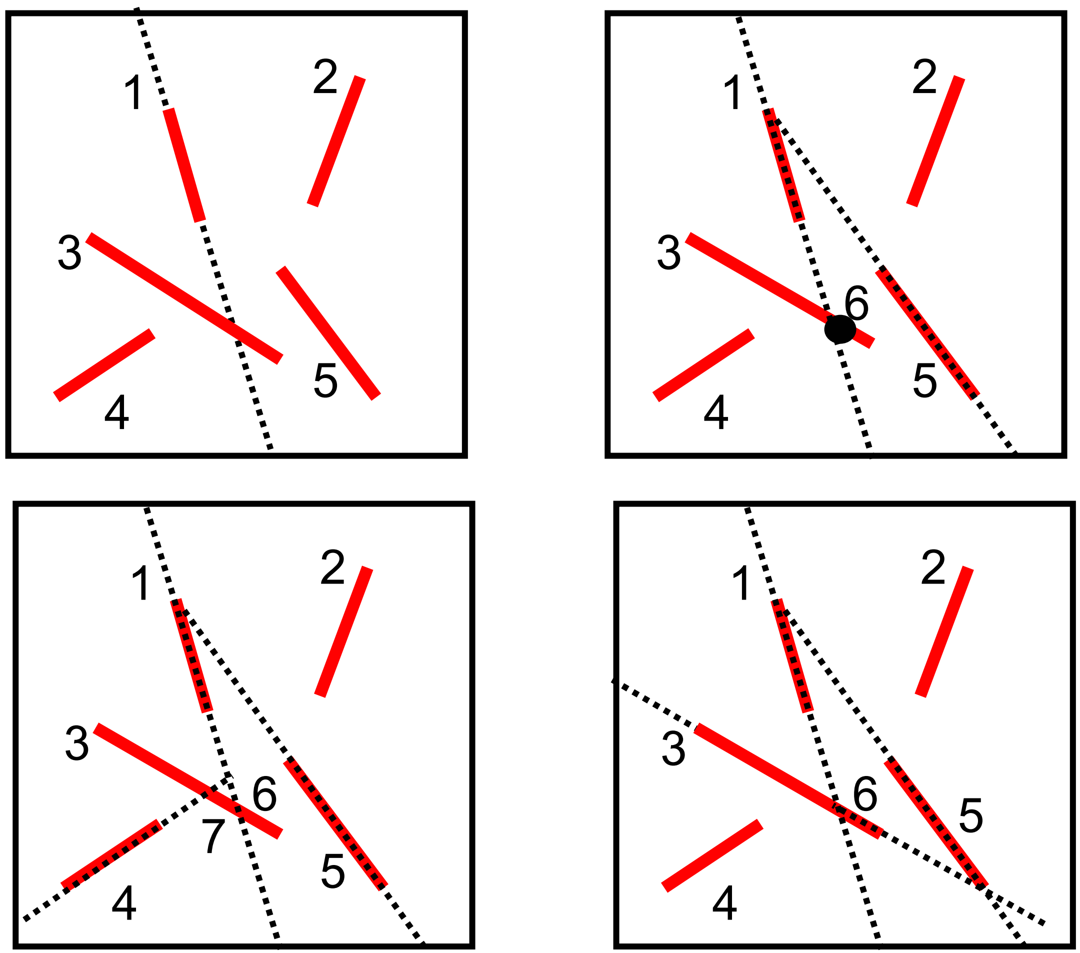
- Tests 3 and 4 in **Depth Sort** technique can be exploited efficiently with **BSP-Trees**:
  - Let L_p be the plane P lies in. The 3D space may be divided into the following three groups:
    - Polygons in front of L_p
    - Polygons behind L_p
    - Polygons intersecting L_p
  - Polygons in the third class are split, and resulting polygons are classified into the first two classes
  - As a result of the subdivision with respect to L_p:
    - The polygons behind L_p cannot obscure P, so we can draw them first
    - P cannot obscure the polygons in front of L_p so we can draw P second
    - Finally we draw the polygons in front of P

Binary Space Partitioning Tree

- **BSP Tree Algorithm**:
  - Construction of the BSP tree:
    - Pick a polygon, let its supporting plane be the root of the tree
    - Create two lists of polygons: those in front, and those behind (splitting polygons if necessary)
    - Recurse on the two lists to create two sub-trees
  - Display:
    - Traverse the BSP tree back to front, drawing polygons in the order they are encountered in the traversal

Binary Space Partitioning Tree

- Example:

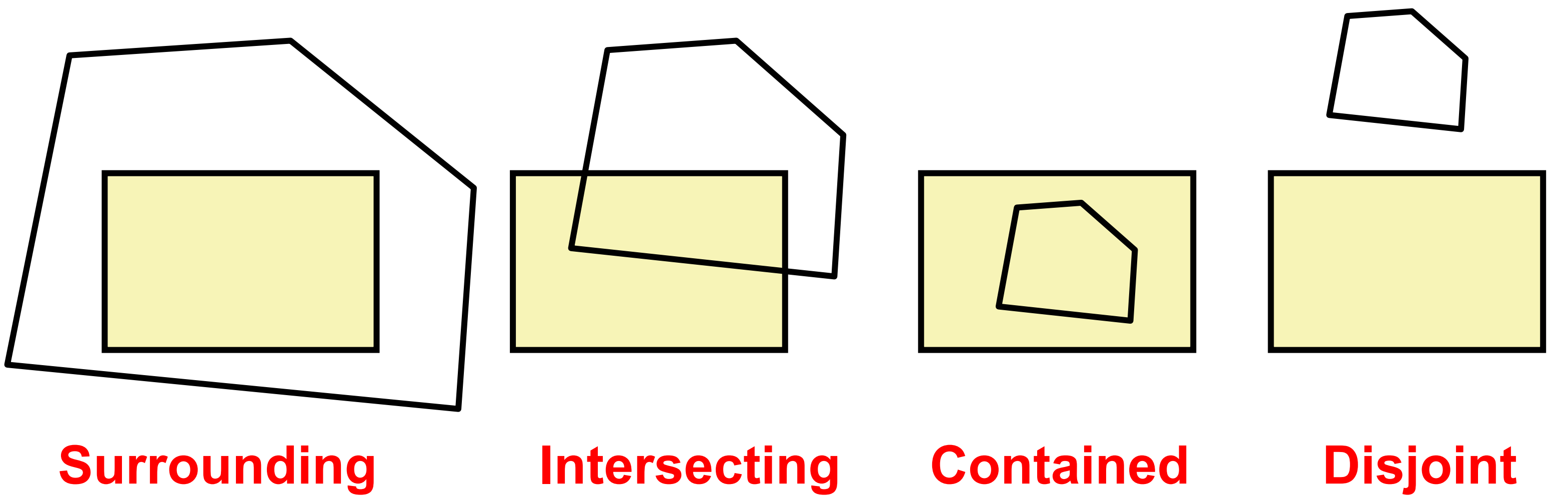


Binary Space Partitioning Tree

- **Properties**:
  - The BSP tree is **view independent**
  - The BSP tree is constructed using the geometry of the object only
  - The tree can be used for hidden surface removal at an arbitrary direction
  - BSP tree is an **object-precision** algorithm

Area Subdivision Algorithms

- **Warnock's Algorithm**:
  - Subdivide screen area recursively, until visible surfaces are easy to determine
  - Each polygon has one of four relationships to the area of interest:



Area Subdivision Algorithms

- **Warnock's Algorithm**:
  - If all polygons are disjoint from the area, fill area with background color
  - Only one intersecting or contained polygon: First fill with background color, then scan convert polygon
  - Only one surrounding polygon: Fill area with polygon's color
  - More than one polygon is surrounding, intersecting, or contained, but one surrounding polygon is in front of the rest: Fill area with polygon's color
  - If none of the above cases occurs: Subdivide area into four parts, and recurse

Area Subdivision Algorithms

- **Warnock's Algorithm**:
  - When the resolution of the image is reached, polygons are sorted by their Z-values at the center of the pixel, and the color of the closest polygon is used
- **Image-precision** technique