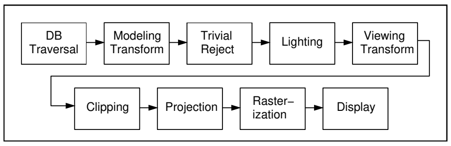
COS 426 Lecture Notes #7

3D Hidden Surface Removal

Rendering Pipeline



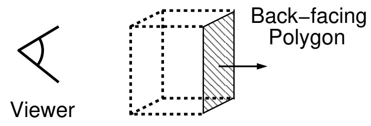
Sample Rendering Pipeline

Hidden Surface Removal (HSR)

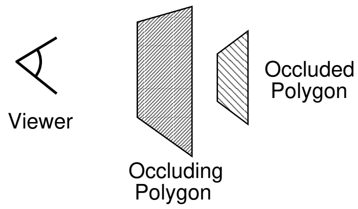
- **Motivation**
- **Algorithms for HSR**
  - Back–face detection
  - Painter's algorithm
  - Ray casting
  - Scan–line
  - Z–buffer
  - Area subdivision
- **Tradeoffs**

HSR Motivation

- **Surfaces may be back–facing:**

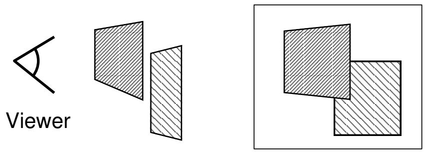


- **Surfaces may be occluding:**

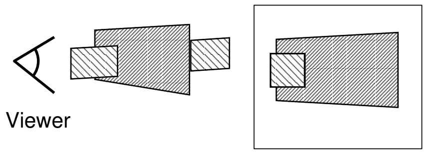


HSR Motivation (cont)

- **Surfaces may be overlapping:**



- **Surfaces may be intersecting:**

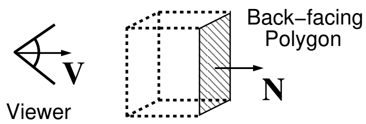


HSR Algorithms

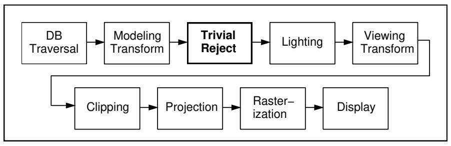
- Back–face detection
- Depth sort
- Ray casting
- Scan–line
- Z–buffer
- Area subdivision

Back–Face Detection

- Do not render any surface oriented away from viewer

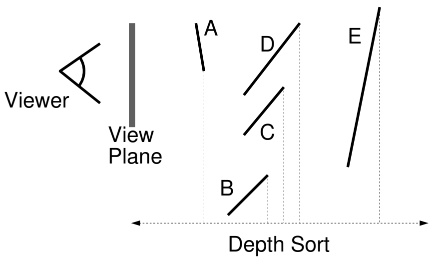


A polygon is backfacing to the viewer if V • N > 0



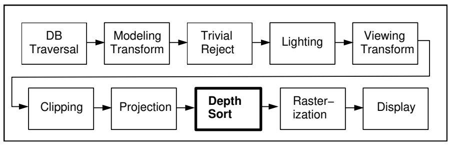
Depth Sort

- **Painter's Algorithm:**
  1) Sort surfaces in order of decreasing maximum depth
  2) Scan convert surfaces in order starting with ones of greatest depth, reordering as necessary based on overlaps.



Depth Sort (cont)

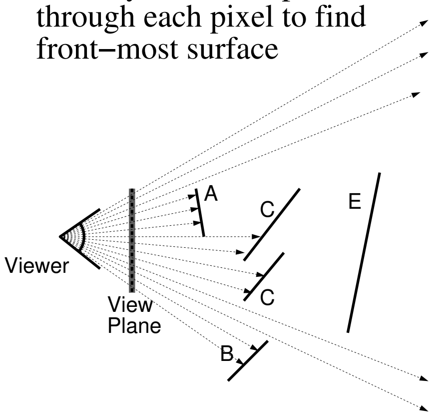
- **Comments**
  - O(nlogn)
  - Intersecting polygons must be subdivided
  - Sort order has lots of frame–to–frame coherence during walkthroughs
  - Must fully compute every pixel for every polygon
  - Used most often with BSP or static list–ordering



Ray Casting

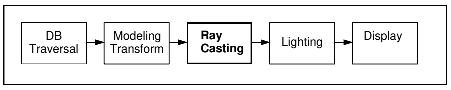
- **Algorithm:**

  Cast ray from viewpoint through each pixel to find front–most surface



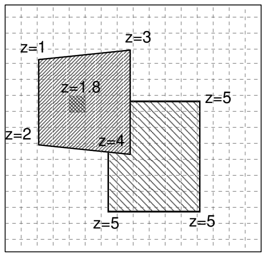
Ray Casting (cont)

- **Comments**
  - O(plogn) for p pixels
  - May (or may not) utilize pixel–to–pixel coherence
  - Conceptually simple, but not generally used



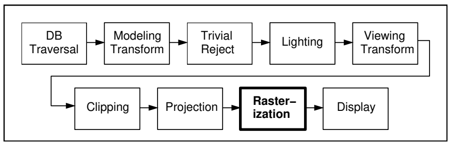
Z–Buffer

- **Algorithm:**
  - Store color ***and depth*** of closest surface for each pixel in frame buffer
  - As scan convert, update only pixels whose (interpolated) depth is closer than the depth stored in the frame buffer



Z Buffer (cont)

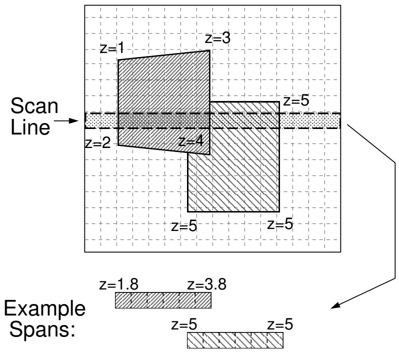
- **Comments**
  - Polygons can be rasterized in any order
  - Requires lots of memory (e.g., 1K x 1K x 24 bits)
  - Requires per pixel processing, subject to aliasing (A−buffer)
  - Commonly implemented in hardware



Scan−Line

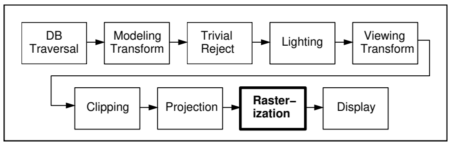
- **Algorithm:**

  For each scan line, construct ***spans*** and sort by depth



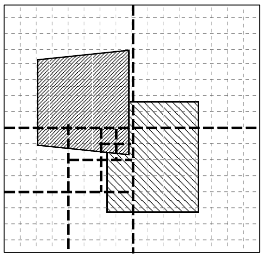
Scan−Line

- **Comments**
  - Fully compute only front−most pixels
  - Coherence along scan lines
  - Commonly implemented in software



Area Subdivision

- **Warnock Algorithm:**
  - Fill area if:
    - All surfaces are outside
    - Only one surface intersects
    - One surface occludes other surfaces within area.
  - Otherwise, subdivide



Conclusion

- **Hidden surface algorithms**
  - Back–face detection
  - Depth sort
  - Ray casting
  - Z–buffer
  - Scan–line
  - Area subdivision
- **Hardware**
  - Z–buffer
- **Software**
  - Depth sort
  - Scan–line