3D Hidden Surface Removal

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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:

Viewers

♦ Surfaces may be intersecting:

Viewers

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

Viewer

A polygon is backfacing to the viewer if \( \mathbf{V} \cdot \mathbf{N} > 0 \)

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**
  - $O(n \log n)$
  - 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**
  - $O(p \log n)$ for $p$ pixels
  - May (or may not) utilize pixel–to–pixel coherence
  - Conceptually simple, but not generally used

Z–Buffer

- **Algorithm:**
  - Store color \textit{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

Example Spans:

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