

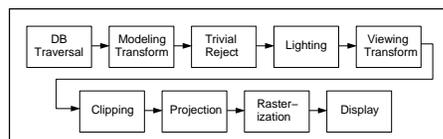
3D Hidden Surface Removal

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Course Outline

- ◆ User interaction
 - ◆ Signal processing
 - ◆ 2D rendering
 - Geometry
 - Transforms, clipping
 - ◆ 3D rendering
 - Geometry
 - Transforms, clipping
 - Viewing, projections
 - **Hidden surface removal**
 - **Lighting**
 - **Texture mapping**
 - **Ray tracing, radiosity**
- and more

Rendering Pipeline



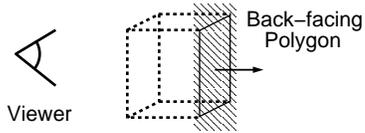
Sample Rendering Pipeline

Hidden Surface Removal (HSR)

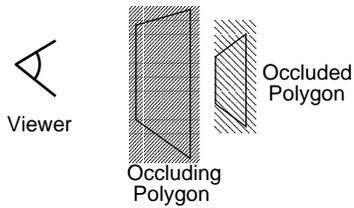
- ◆ **Motivation**
- ◆ **Algorithms for HSR**
 - Back-face detection
 - Painter's algorithm
 - Ray casting
 - Scan-line
 - Z-buffer
 - Area subdivision
- ◆ **Tradeoffs**

HSR Motivation

- ◆ Surfaces may be back-facing:

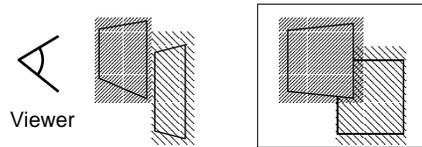


- ◆ Surfaces may be occluding:

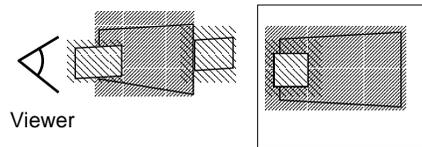


HSR Motivation (cont)

- ◆ Surfaces may be overlapping:



- ◆ Surfaces may be intersecting:

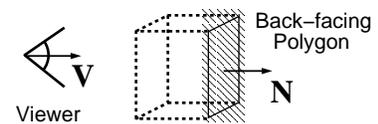


HSR Algorithms

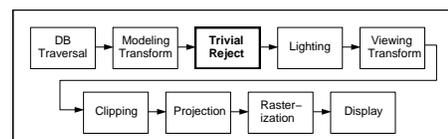
- ◆ Back-face detection
- ◆ Depth sort
- ◆ Ray casting
- ◆ Scan-line
- ◆ Z-buffer
- ◆ Area subdivision

Back-Face Detection

- ◆ Do not render any surface oriented away from viewer



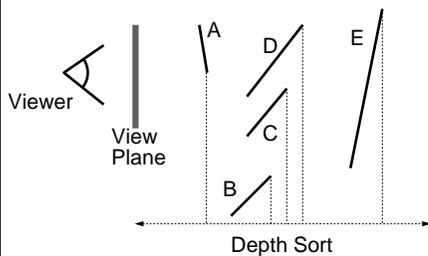
A polygon is backfacing to the viewer if $V \cdot N > 0$



Depth Sort

◆ Painter's Algorithm:

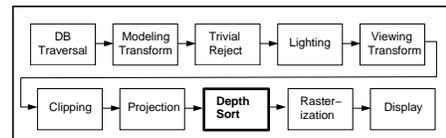
- 1) Sort surfaces in order of decreasing maximum depth
- 2) Scan convert surfaces in order starting with ones of greatest depth, reordering as necessary based on overlaps.



Depth Sort (cont)

◆ Comments

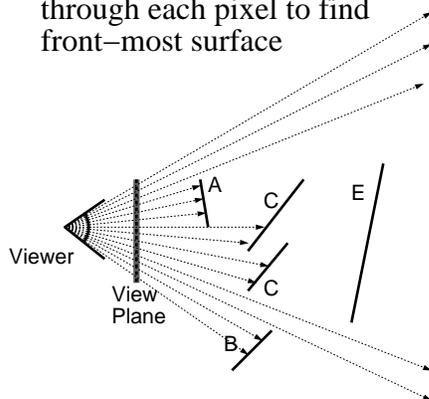
- $O(n \log n)$
- Intersecting polygons must be subdivided
- Sort order has lots of frame-to-frame coherence during walkthroughs
- Must fully compute every pixel for every polygon
- Used most often with BSP or static list-ordering



Ray Casting

◆ Algorithm:

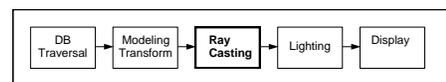
Cast ray from viewpoint through each pixel to find front-most surface



Ray Casting (cont)

◆ Comments

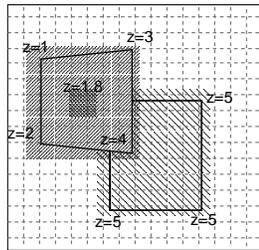
- $O(p \log n)$ for p pixels
- May (or may not) utilize pixel-to-pixel coherence
- Conceptually simple, but not generally used



Z-Buffer

◆ Algorithm:

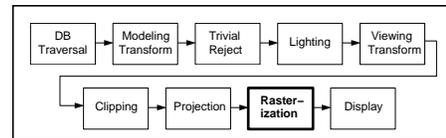
- Store color *and depth* of closest surface for each pixel in frame buffer
- As scan convert, update only pixels whose (interpolated) depth is closer than the depth stored in the frame buffer



Z Buffer (cont)

◆ Comments

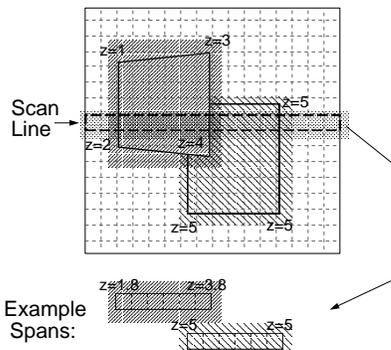
- Polygons can be rasterized in any order
- Requires lots of memory (e.g., 1K x 1K x 24 bits)
- Requires per pixel processing, subject to aliasing (A-buffer)
- Commonly implemented in hardware



Scan-Line

◆ Algorithm:

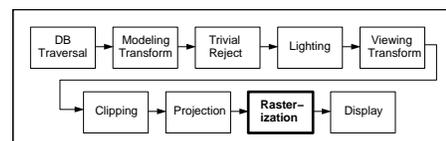
For each scan line, construct *spans* and sort by depth



Scan-Line

◆ Comments

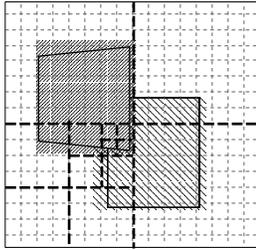
- Fully compute only front-most pixels
- Coherence along scan lines
- Commonly implemented in software



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