CS-184: Computer Graphics

Lecture #10: Clipping and Hidden Surfaces

Prof. James O'Brien
University of California, Berkeley

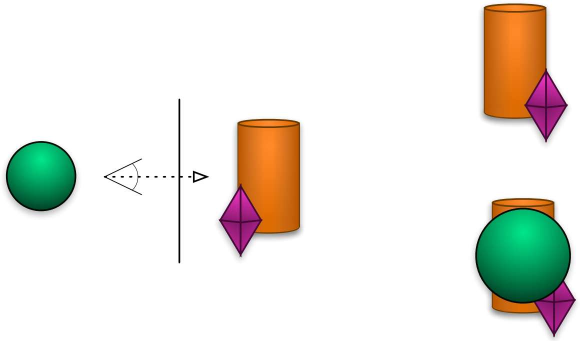
V2009-F-10-1.0

Today

- Clipping
  - Clipping to view volume
  - Clipping arbitrary polygons
- Hidden Surface Removal
  - Z-Buffer
  - BSP Trees
  - Others

Clipping

- Stuff outside view volume should not be drawn
  - Too close: obscures view



Clipping

- Stuff outside view volume should not be drawn
  - Too close: obscures view
  - Too far:
    - Complexity
    - Z-buffer problems
  - Too high/low/right/left:
    - Memory errors
    - Broken algorithms
    - Complexity

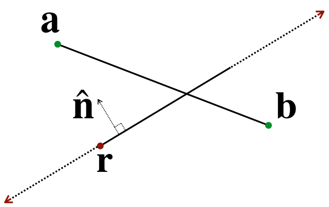
Clipping Line to Line/Plane

Line segment to be clipped

$$\mathbf{x}(t) = \mathbf{a} + t(\mathbf{b} - \mathbf{a})$$

Line/plane that clips it

$$\hat{\mathbf{n}} \cdot \mathbf{x} - \hat{\mathbf{n}} \cdot \mathbf{r} = 0$$



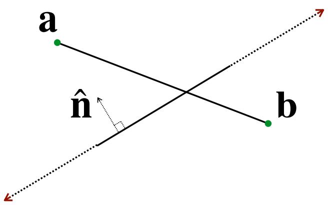
Clipping Line to Line/Plane

Line segment to be clipped

$$\mathbf{x}(t) = \mathbf{a} + t(\mathbf{b} - \mathbf{a})$$

Line/plane that clips it

$$\hat{\mathbf{n}} \cdot \mathbf{x} - f = 0$$



Clipping Line to Line/Plane

Line segment to be clipped

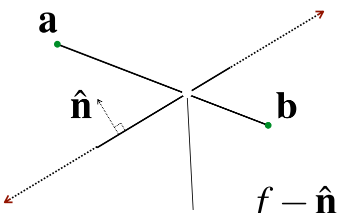
$$\mathbf{x}(t) = \underbrace{\mathbf{a} + t(\mathbf{b} - \mathbf{a})}$$

Line/plane that clips it

$$\hat{\mathbf{n}} \cdot \mathbf{x} - f = 0$$

$$\hat{\mathbf{n}} \cdot (\mathbf{a} + t(\mathbf{b} - \mathbf{a})) - f = 0$$

$$\hat{\mathbf{n}} \cdot \mathbf{a} + t(\hat{\mathbf{n}} \cdot (\mathbf{b} - \mathbf{a})) - f = 0$$



$$t = \frac{f - \hat{\mathbf{n}} \cdot \mathbf{a}}{\hat{\mathbf{n}} \cdot \mathbf{d}}$$

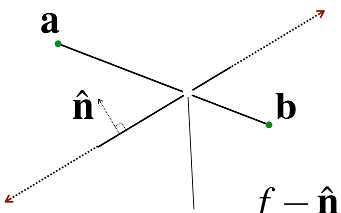
Clipping Line to Line/Plane

- Segment may be on one side

$$t \notin [0 \ldots 1]$$

- Lines may be parallel

$$\hat{\mathbf{n}} \cdot \mathbf{d} = 0$$



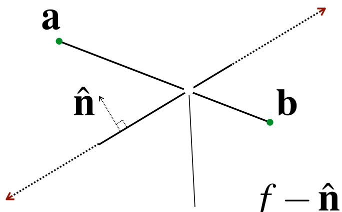
$$t = \frac{f - \hat{\mathbf{n}} \cdot \mathbf{a}}{\hat{\mathbf{n}} \cdot \mathbf{d}}$$

Clipping Line to Line/Plane

- Segment may be on one side

$$t \notin [0 \ldots 1]$$

- Lines may be parallel

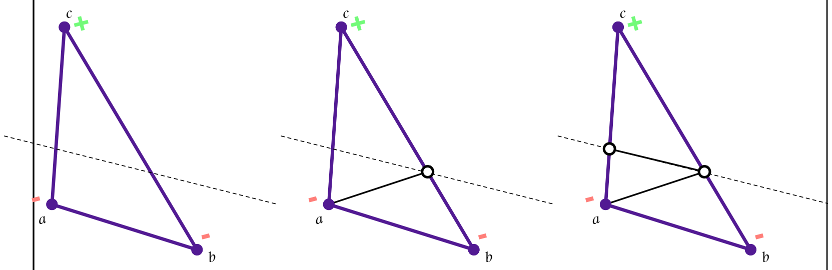


$$t = \frac{f - \hat{\mathbf{n}} \cdot \mathbf{a}}{\hat{\mathbf{n}} \cdot \mathbf{d}}$$

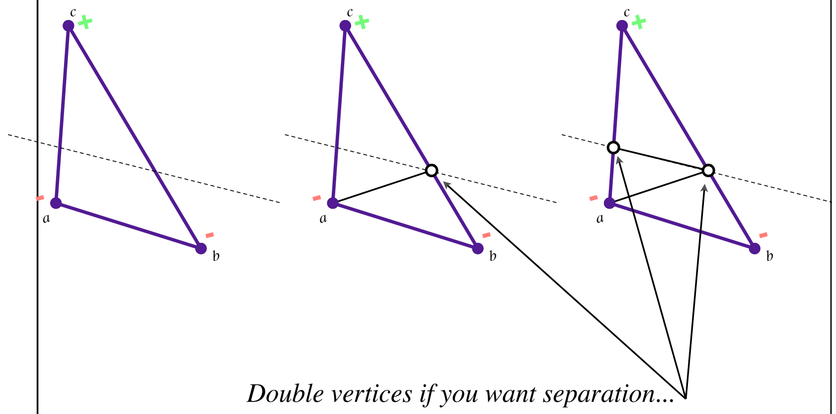
$$\hat{\mathbf{n}} \cdot \mathbf{d} = 0$$

$$|\hat{\mathbf{n}} \cdot \mathbf{d}| \leq \varepsilon$$ (Recall comments about numerical issues)

Triangle Clip/Split



Triangle Clip/Split

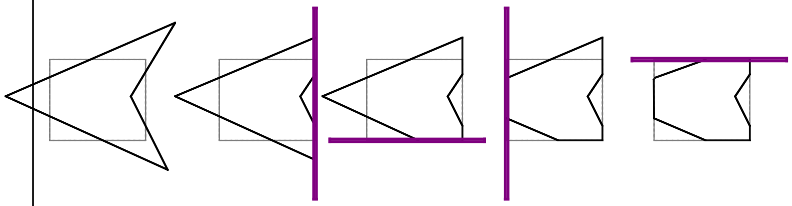


Double vertices if you want separation…

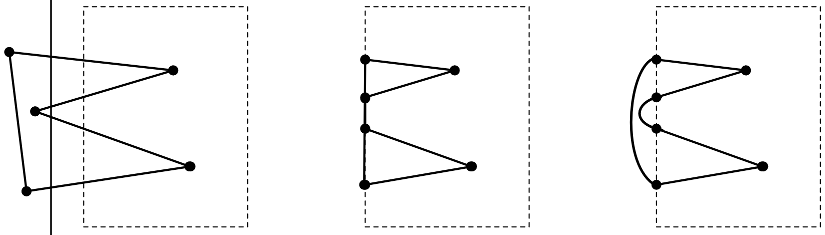
Polygon Clip to Convex Domain

- Convex domain defined by collection of planes (or lines or hyper-planes)
- Planes have outward pointing normals
- Clip against each plane in turn
- Check for early/trivial rejection

Polygon Clip to Convex Domain

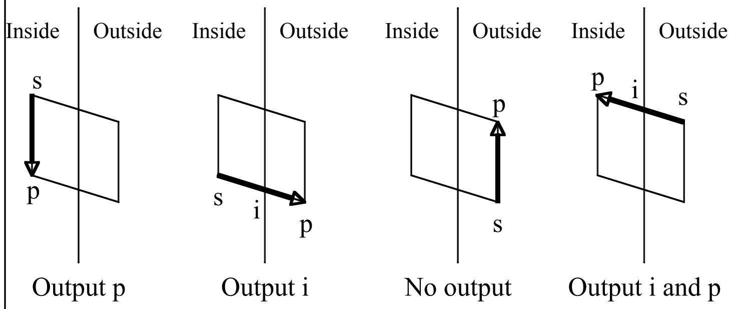


Polygon Clip to Convex Domain



Note double edges.

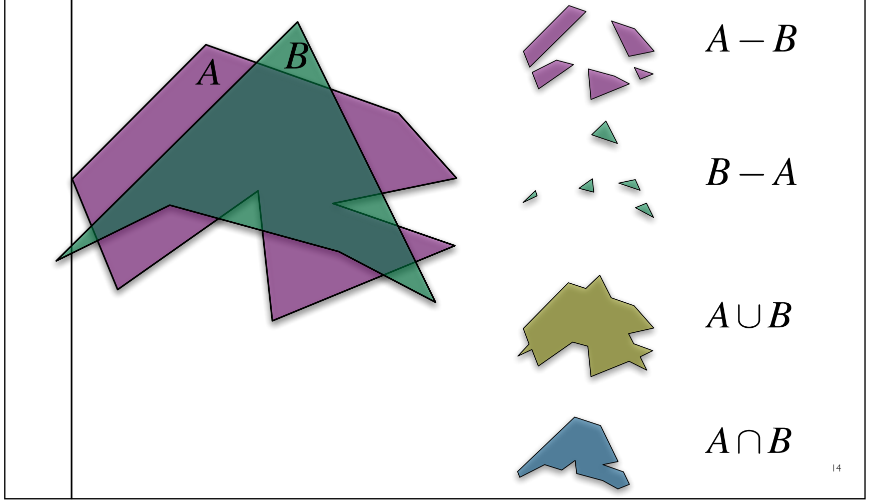
Polygon Clip to Convex Domain



Polygon Clip to Convex Domain

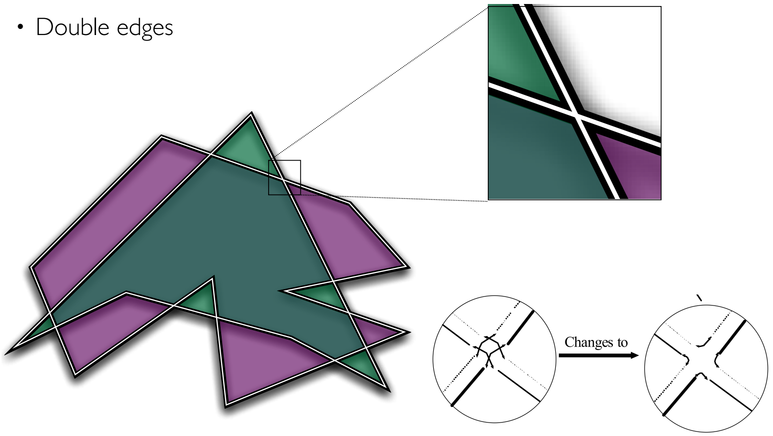
- Sutherland-Hodgman algorithm
  - Basically edge walking
- Clipping done often... should be efficient
  - Liang-Barsky parametric space algorithm
  - See text for clipping in 4D homogenized coordinates

General Polygon Clipping



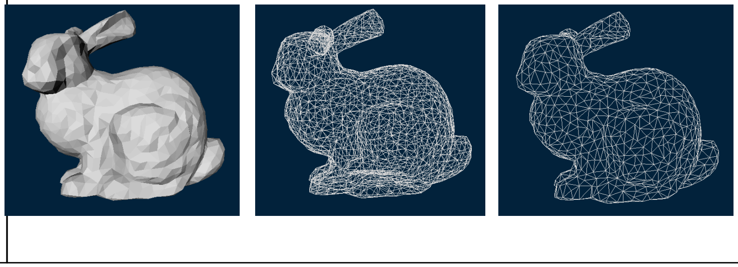
General Polygon Clipping

- Weiler Algorithm
  - Double edges



Hidden Surface Removal

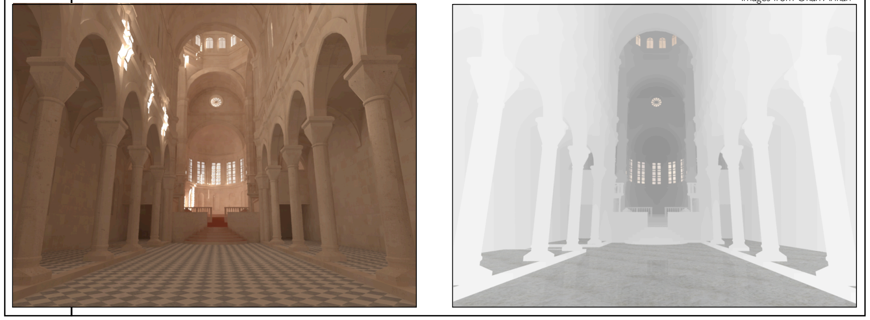
- True 3D to 2D projection would put every thing overlapping into the view plane.
- We need to determine what's in front and display only that.



Z-Buffers

- Add extra depth channel to image
- Write Z values when writing pixels
- Test Z values before writing

Images from Okan Arikan

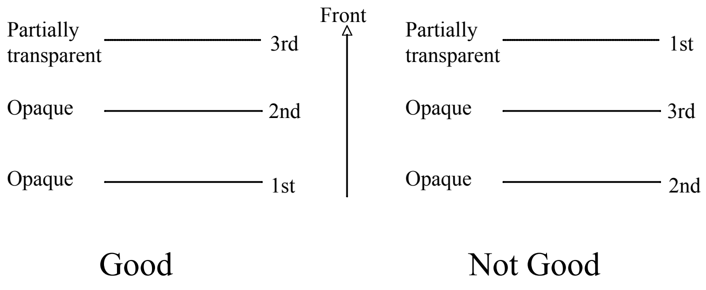


Z-Buffers

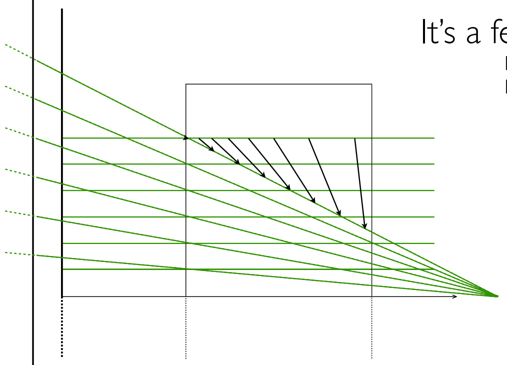
- Benefits
  - Easy to implement
  - Works for most any geometric primitive
  - Parallel operation in hardware
- Limitations
  - Quantization and aliasing artifacts
  - Overfill
  - Transparency does not work well

Z-Buffers

- Transparency requires partial sorting:



Z-Buffers



Recall depth-value distortions.

It's a feature...

More resolution near viewer
Best use of limited precision

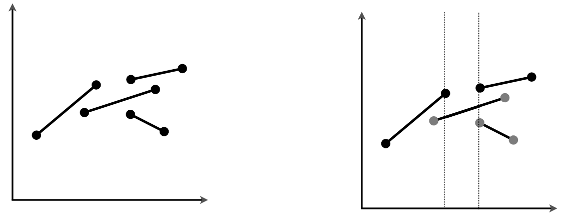
A-Buffers

- Store sorted list of "fragments" at each pixel
- Draw all opaque stuff first then transparent
- Stuff behind full opacity gets ignored

- Nice for antialiasing...

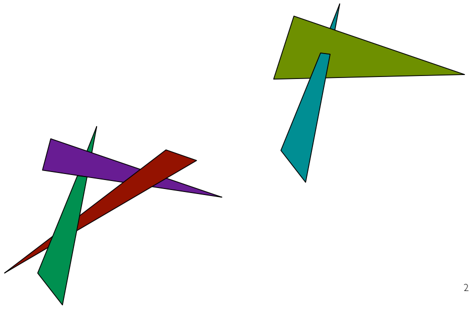
Scan-line Algorithm

- Assume polygons don't intersect
- Each time an edge is crossed determine who's on top



Painter's Algorithm

- Sort Polygons Front-to-Back
  - Draw in order
  - Back-to-Front works also, but wasteful
- How to sort quickly?
- Intersecting polygons?
- Cycles?



BSP-Trees

- Binary Space Partition Trees
  - Split space along planes
  - Allows fast queries of some spatial relations
- Draw Front-to-Back
  - Draw same-side polygons first
  - Draw root node polygon (if any)
  - Draw other-side polygons last