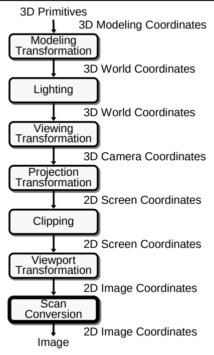
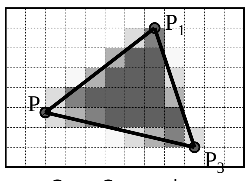
Scan Conversion & Shading

Taken from Thomas Funkhouser

3D Rendering Pipeline (for direct illumination)





Scan Conversion & Shading

Overview

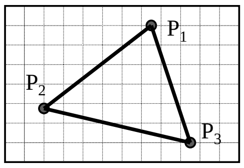
- Scan conversion
  - Figure out which pixels to fill
- Shading
  - Determine a color for each filled pixel

Scan Conversion

- Render an image of a geometric primitive by setting pixel colors

```
void SetPixel(int x, int y, Color rgba)
```

- Example: Filling the inside of a triangle



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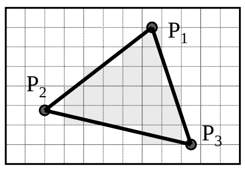
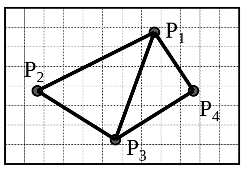


Triangle Scan Conversion

- Properties of a good algorithm
  - Symmetric
  - Straight edges
  - Antialiased edges
  - No cracks between adjacent primitives
  - MUST BE FAST!



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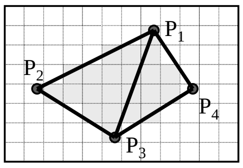
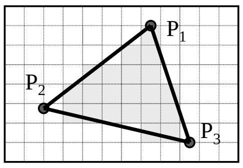


Simple Algorithm

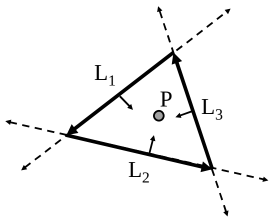
- Color all pixels inside triangle

```
void ScanTriangle(Triangle T, Color rgba){
   for each pixel P at (x,y){
      if (Inside(T, P))
         SetPixel(x, y, rgba);
   }
}
```



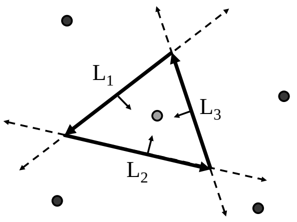
Inside Triangle Test

- A point is inside a triangle if it is in the positive halfspace of all three boundary lines
  - Triangle vertices are ordered counter-clockwise
  - Point must be on the left side of every boundary line



Inside Triangle Test

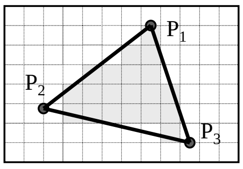
```
Boolean Inside(Triangle T, Point P)
{
   for each boundary line L of T {
      Scalar d = L.a*P.x + L.b*P.y + L.c;
      if (d < 0.0) return FALSE;
   }
   return TRUE;
}
```



Simple Algorithm

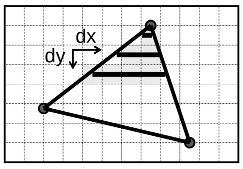
- What is bad about this algorithm?

```
void ScanTriangle(Triangle T, Color rgba){
   for each pixel P at (x,y){
      if (Inside(T, P))
         SetPixel(x, y, rgba);
   }
}
```



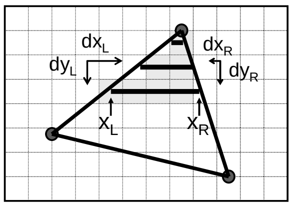
Triangle Sweep-Line Algorithm

- Take advantage of spatial coherence
  - Compute which pixels are inside using horizontal spans
  - Process horizontal spans in scan-line order
- Take advantage of edge linearity
  - Use edge slopes to update coordinates incrementally



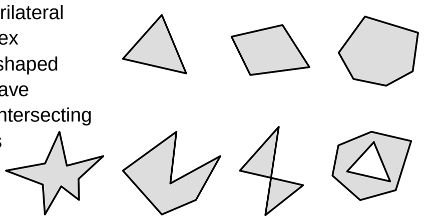
Triangle Sweep-Line Algorithm

```
void ScanTriangle(Triangle T, Color rgba){
   for each edge pair {
       initialize x_L, x_R;
       compute dx_L/dy_L and dx_R/dy_R;
       for each scanline at y
          for (int x = x_L; x <= x_R; x++)
              SetPixel(x, y, rgba);
       x_L += dx_L/dy_L;
       x_R += dx_R/dy_R;
   }
}
```



Polygon Scan Conversion

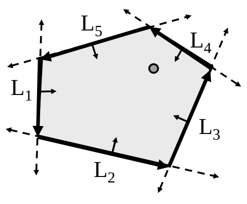
- Fill pixels inside a polygon
  - Triangle
  - Quadrilateral
  - Convex
  - Star-shaped
  - Concave
  - Self-intersecting
  - Holes



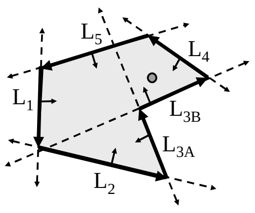
What problems do we encounter with arbitrary polygons?

Polygon Scan Conversion

- Need better test for points inside polygon
  - Triangle method works only for convex polygons



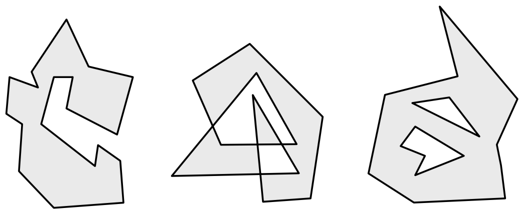
Convex Polygon



Concave Polygon

Inside Polygon Rule

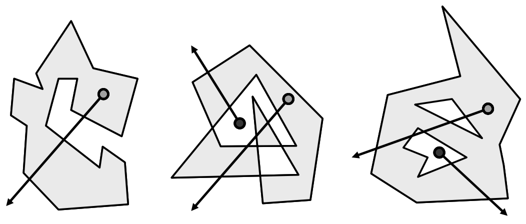
- What is a good rule for which pixels are inside?



Concave   Self-Intersecting   With Holes

Inside Polygon Rule

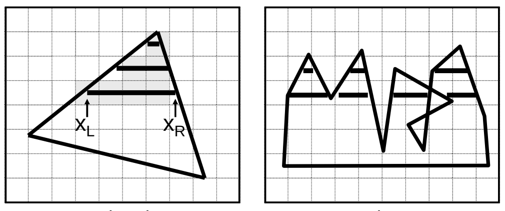
- Odd-parity rule
  - Any ray from P to infinity crosses odd number of edges



Concave   Self-Intersecting   With Holes

Polygon Sweep-Line Algorithm

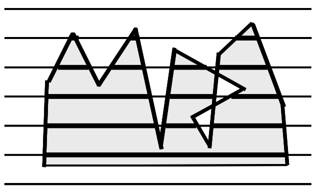
- Incremental algorithm to find spans, and determine insideness with odd parity rule
  - Takes advantage of scanline coherence



Triangle   Polygon

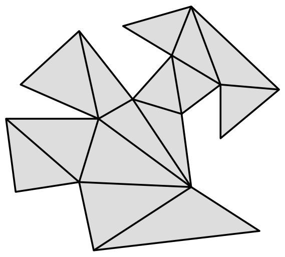
Polygon Sweep-Line Algorithm

```
void ScanPolygon(Triangle T, Color rgba){
   sort edges by maxy
   make empty “active edge list”
   for each scanline (top-to-bottom) {
      insert/remove edges from “active edge list”
      update x coordinate of every active edge
      sort active edges by x coordinate
      for each pair of active edges (left-to-right)
         SetPixels(x_i, x_i+1, y, rgba);
      }
}
```



Hardware Scan Conversion

- Convert everything into triangles
  - Scan convert the triangles



Hardware Antialiasing

- Supersample pixels
  - Multiple samples per pixel
  - Average subpixel intensities (box filter)
  - Trades intensity resolution for spatial resolution