Chapter 9

Clipping

The Rendering Pipeline

Geometry Database
Model/View Transform.
Lighting
Perspective Transform.
Clipping

Scan Conversion
Texturing
Depth Test
Blending
Frame-buffer

Line and Polygon Clipping (2D)

Objectives
- Efficiency
- Memory access

Analytic Solution

Intersection of convex regions is convex

- Why?
  - \( L \& D \) are convex - intersection is convex
  - single connected segment of \( L \)

- Question: Can boundary of two convex shapes intersect more than twice?
  - Clipping - compute intersection of \( L \)
    with four boundary segments of window \( D \)

Line-Line Intersection

Intersection:
\[
x, y \text{ values equal in both representations - two linear equations in two unknowns } (r, t)
\]

Intersection with vertical/horizontal lines

Intersection:
\[
x, y \text{ values equal in both representations - two linear equations in two unknowns } (r, t)
\]

Copyright Alla Sheffer
UBC 2004
Cohen-Sutherland Algorithm

**Purpose:**
Fast treatment of line segments that are trivially inside/outside window.

Idea:
Assign to \( P \) a binary code consisting of a bit for each edge of \( D \), using lookup table:

<table>
<thead>
<tr>
<th>Bit</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( x &lt; x_{\text{min}} )</td>
<td>( x &gt; x_{\text{max}} )</td>
</tr>
<tr>
<td>2</td>
<td>( y &gt; y_{\text{max}} )</td>
<td>( y &lt; y_{\text{min}} )</td>
</tr>
<tr>
<td>3</td>
<td>( x &gt; x_{\text{max}} )</td>
<td>( x &lt; x_{\text{min}} )</td>
</tr>
<tr>
<td>4</td>
<td>( y &gt; y_{\text{max}} )</td>
<td>( y &lt; y_{\text{min}} )</td>
</tr>
</tbody>
</table>

Cohen-Sutherland Algorithm (cont’d)

Given \( L \) from \((x_1, y_1), (x_2, y_2)\) & rectangle \( D \).

If bitwise and of the codes of \((x_1, y_1)\) and \((x_2, y_2)\) is not zero, or the bitwise or is zero, then \( L \) can be trivially handled (it is either totally outside or totally inside \( D \)).

Why?

3D clipping

- Determine portion of line inside axis-aligned parallelepiped (viewing frustum in NDC)
- Simple extension to 2D algorithms
- After perspective transform
  - means that clipping volume always the same
  - \( \text{xmin} = \text{ymin} = -1, \text{xmax} = \text{ymax} = 1 \) in OpenGL
  - boundary lines become boundary planes
  - but bit-codes still work the same way
  - additional front and back clipping plane
    - \( \text{zmin} = -1, \text{zmax} = 1 \) in OpenGL

Cohen-Sutherland Algorithm for convex polygons

C-S-Clip (poly \( P_1, P_2, \ldots, P_n, x_{\text{min}}, y_{\text{min}}, y_{\text{max}}, x_{\text{max}} \))

If \( n = 1 \) then \( C \) if \( n > 1 \) then:

How does intersection of rectangle & triangle looks like?
- How many sides?
- How to expand clipping to triangles?
- Hint: it is convex
- Will develop on the board...

Copyright Alla Sheffer
UBC 2004