Clipping

Extraction of data/primitives inside a region of interest “window”
=> Discard (parts of ) primitives outside window.

Point Clipping: Remove points outside window.
• A point is either entirely inside the window or not

\[
\begin{align*}
(x_L, y_B) & \leq (x, y) \leq (x_R, y_T) \\
P & \text{is outside} \\
Q & \text{is inside}
\end{align*}
\]
Clipping

Line Clipping: Remove portion of line segment outside window

• Can we use point clipping for the end points?

Point clipping works
Clipping

Line Clipping: Remove portion of line segment outside window

• How about these lines?

Point clipping does not work
Clipping

Cohen and Sutherland
Clipping

Cohen and Sutherland

4 bit code to indicate the zone of end points of line with respect to window
Clipping

Cohen and Sutherland

4 bit code to indicate the zone of end points of line with respect to window
Clipping

Cohen and Sutherland

Trivially accept case
  • line is totally visible
  • if both ends of the line have outcode as 0000

Trivially accept
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Trivially reject case
• line is totally invisible
• logical AND of the two end points outcodes

Trivially reject
Clipping

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If not trivially reject and accept case
  • line is potentially visible

Potentially visible
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If potentially visible
• subdivide into segments and apply trivial acceptance and rejection test
• segments by intersection with window edges
• edges in any order but consistent (e.g., top-bottom, right-left)

Result
Clipping

Cohen and Sutherland

- simple, still popular
- limited to rectangular region
- extension to 3D clipping using 3D orthographic view volume is straightforward
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• any convex region

Parametric line (input line AB):

\[ L(t) = A + (B - A)t; t \in (0, 1) \]
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Implicit line (window edge):

$$I(Q) = (Q - P) \cdot n$$

Tells us on which side of the line the point $Q$ is.
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Evaluate

\[ I(Q) = (Q - P).n \]

If > 0 inside halfspace of line (plane)
If < 0 outside halfspace of line (plane)
If = 0 on the line

Should give indications for trivial accept and reject cases.
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Window edge

Line segment

Trivial Reject

Trivial Accept

\[ I(Q) = (Q - P).n \]

\[ L(t) = A + t(B - A) \]

\[ I(A) < 0 \text{ AND } I(B) < 0 \]

\[ I(A) > 0 \text{ AND } I(B) > 0 \]
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\[ L(t) = A + (B - A)t \]
\[ I(Q) = (Q - P).n \]
\[ I(L(t)) = 0; \text{solve for } t \]
\[ (L(t) - P).n = 0 \]
\[ (A + t(B - A) - P).n = 0 \]
\[ (A - P).n + t(B - A).n = 0 \]
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\[
t = \frac{(A - P) \cdot n}{(B - A) \cdot n}
\]

\[
t = \frac{(A - P) \cdot n}{(A - P) \cdot n - (B - P) \cdot n}
\]
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Which ‘t’ to select?

A (t=0)

B (t=1)
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\[ D > 0 \text{ label } t \text{ as } t_E \]

\[ t = \frac{(A - P) \cdot n}{(B - A) \cdot n} \]

Entering
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\[ t = \frac{(A - P) \cdot n}{(B - A) \cdot n} \]

\[ D = (B - A) \cdot n \]

\[ D < 0 \text{ label } t \text{ as } t_L \]

Leaving
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A \((t=0)\)

B \((t=1)\)

n

t of interest:
largest \(t_E\)
smallest \(t_L\)

\(t_E^{\text{max}}\)
\(t_L^{\text{min}}\)
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If $t_E^{\text{max}} > t_L^{\text{min}}$
Reject
Clipping

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Arbitrary Convex Window
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Arbitrary Convex Window

Polygon is convex if for all adjacent edges the sign of cross product is same.

\[ E_1 \times E_2 : \text{positive} \]
\[ E_2 \times E_3 : \text{positive} \]
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Arbitrary Window

$E_1 \times E_2 : positive$
$E_2 \times E_3 : positive$
$E_3 \times E_4 : negative$

Polygon is non-convex
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Arbitrary Window

Make the polygon convex by adding the edge $V_3 V_5$

Clip against the convex polygon
$\Rightarrow P_3 P_4$
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Arbitrary Window

Clip against the triangle
=> $P_5P_4$

Subtract $P_5P_4$ from $P_3P_4$
=> $P_3P_5$