Drawing in 2D

CSCI 4229/5229
Computer Graphics
Fall 2022

Coordinate Systems

- Cartesian coordinates
  - Most commonly used
  - Left or right handed
  - 2D is a trivial case in 3D
- Polar coordinates
  - Convenient in some instances
- Curvilinear Coordinates
  - Specialized applications

2D Cartesian Coordinate Systems

- World Coordinates
  - *Xmin – Xmax* x *Ymin - Ymax*
- Normalized Device Coordinates
  - 0-1 x 0-1 or 0-1 x 0-*r* or -1 to -1
  - may be isometric
  - Viewport *Umin – Umax* x *Vmin – Vmax*
- Device coordinates
  - pixels, plotter increments
  - origin may be top-left

Transformations

- World to Normalized Device Coordinates

  $u = (x\text{-}Xmin)/(Xmax\text{-}Xmin)*(Umax\text{-}Umin) + Umin$

  $v = (y\text{-}Ymin)/(Ymax\text{-}Ymin)*(Vmax\text{-}Vmin) + Vmin$

- Normalized Device to World Coordinates

  $x = (u\text{-}Umin)/(Umax\text{-}Umin)*(Xmax\text{-}Xmin) + Xmin$

  $y = (v\text{-}Vmin)/(Vmax\text{-}Vmin)*(Ymax\text{-}Ymin) + Ymin$

- (x,y) may be outside $(Xmin–Xmax,Ymin\text{-}Ymax)$

Vector Lines

- Line from (x_0,y_0) to (x_1,y_1)
- Explicit
  - $y = (x-x_0)*(y_1-y_0)/(x_1-x_0) + y_0$
  - $x = (y-y_0)*(x_1-x_0)/(y_1-y_0) + x_0$
- Parameteric
  - $x = (1-f)x_0 + f\,x_1$
  - $y = (1-f)y_0 + f\,y_1$
  - $f = 0 \Rightarrow (x_0,y_0)$; $f = 1 \Rightarrow (x_1,y_1)$

Vector Clipping

- Cohen-Sutherland Line Clipping
  - Determine region of start and end
  - Accept, reject or clip
- Parametric Line-Clipping Algorithm
  - Calculate parameter t
  - $0 < t < 1$ requires clipping
- Sutherland-Hodgman Polygon Clipping
  - Clips edges of polygon
  - Successive clips to half planes
- ***OpenGL does this for you***

Cohen-Sutherland Line Clipping

- Set bits to identify outside zones
- Trivial accept or reject
- Clip non-trivial cases
- Accept or reject

Parametric Line Clipping

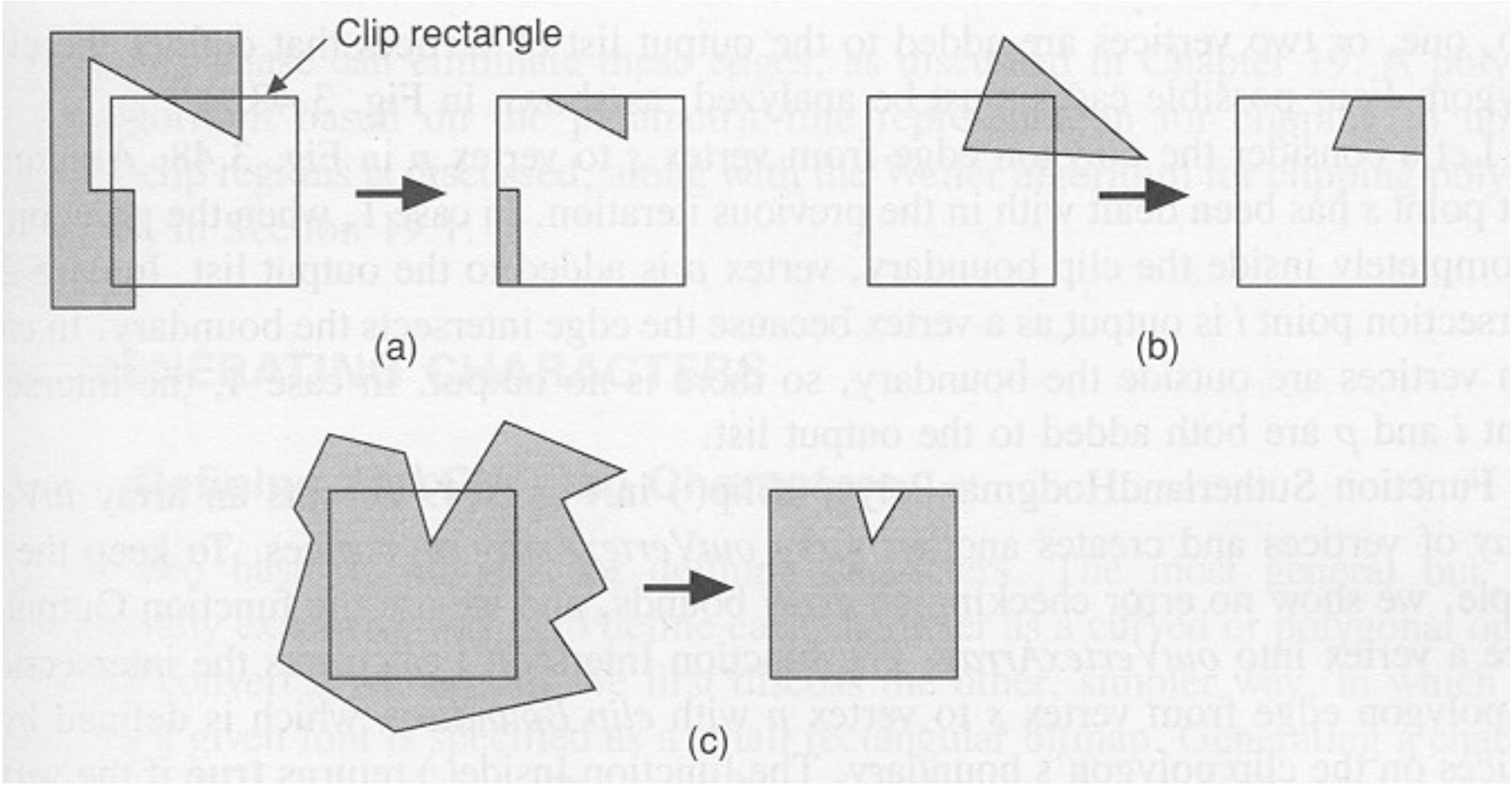
- Cohen-Sutherland may require up to 4 clips
- Parameteric algorithm more efficient
  - Original Cyrus-Beck
  - Improved by Liang-Barsky
- Readily extends to 3D and irregular windows
- Basic equation for line from P_0 to P_1

$$t = (N \cdot [P_0 - P_E]) / (N \cdot [P_0 - P_1])$$

N is the outside normal

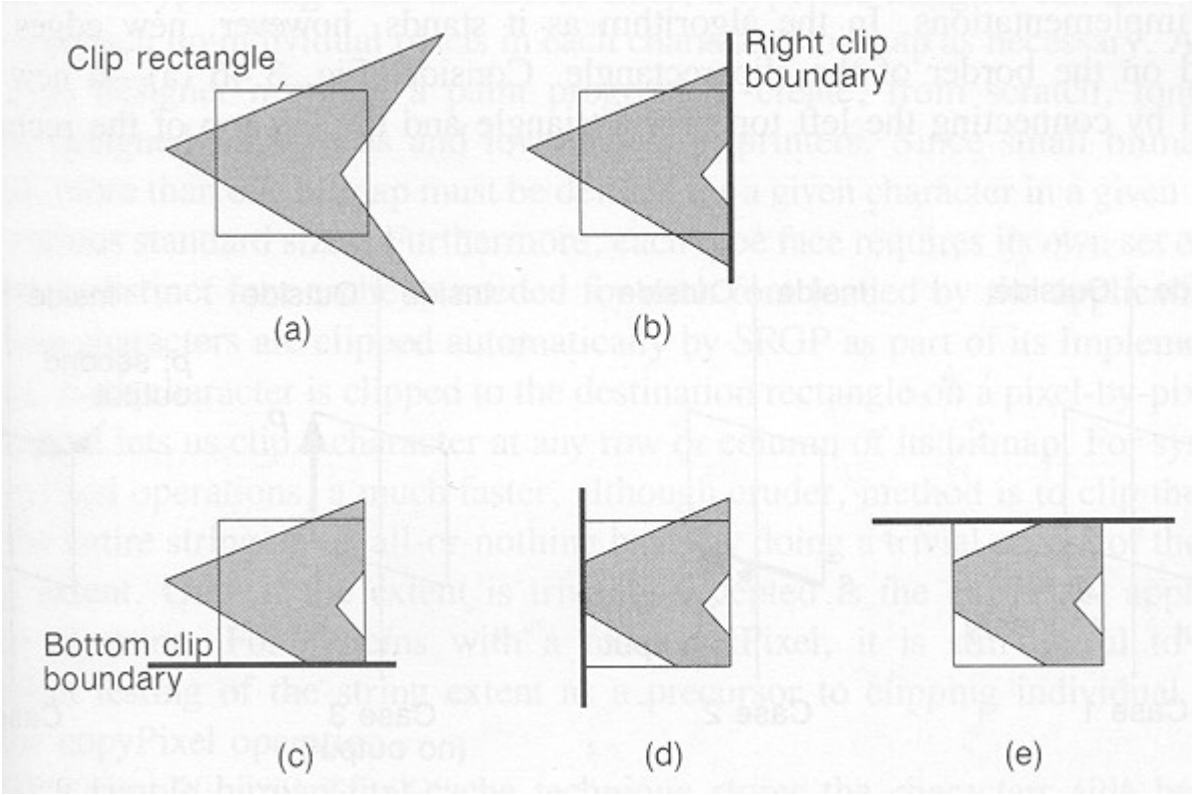
P_E is on the edge

Polygon Clipping Challenges



From *Foley,van Dam Feiner & Hughes*

Polygon Clipping Algorithm



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