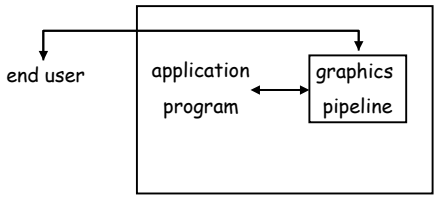
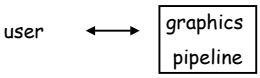
cs155 – z sweedyk

graphics
pipeline
systems

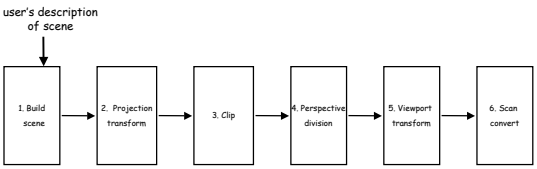
who's who



who's who for today



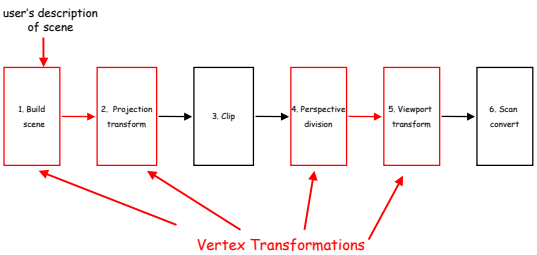
graphics pipeline



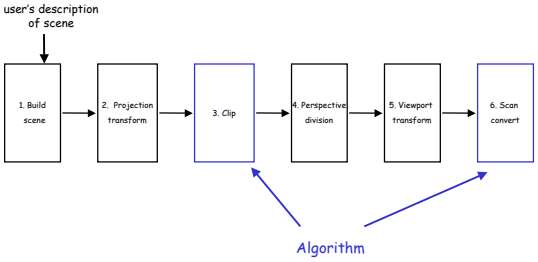
"vertex based" primitives

- points
- lines
- triangles
- convex polygons

graphics pipeline



graphics pipeline



graphics pipeline overview

- simplified pipeline
- general pipeline

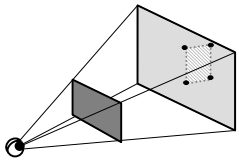
graphics pipeline overview

- simplified pipeline
- general pipeline

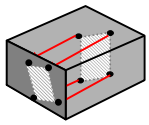
- geometric primitives defined in standardized, homogenous world coordinates
- orthographic projection
- standardized view volume

projection

perspective projection

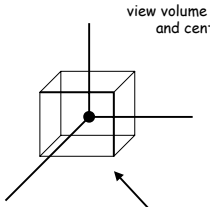


orthographic projection
(viewer at infinity)



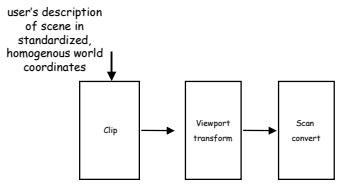
standard orthographic view volume

view volume is 2x2x2, axis-aligned, and centered at the origin



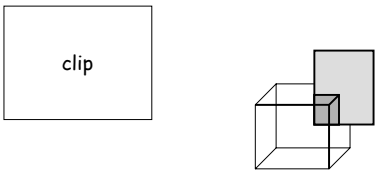
rendered image is the parallel projection of scene onto front plane

simplified graphics pipeline

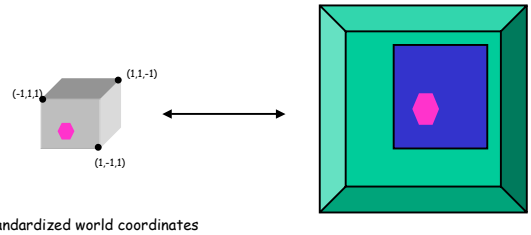


graphics pipeline: clip

eliminate "outside" primitive



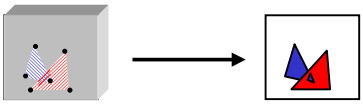
viewport transformation



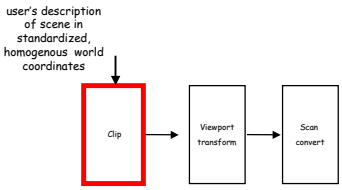
standardized world coordinates

image coordinates

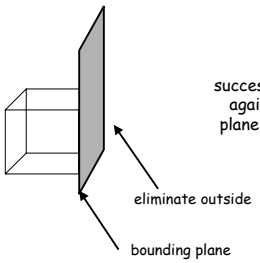
scan conversion



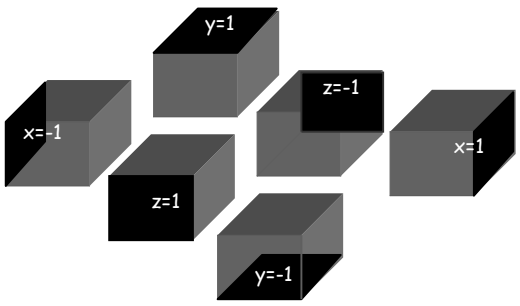
simplified graphics pipeline



3d clipping overview



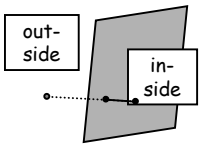
bounding planes of canonical view volume



clipping algorithm

given a clipping plane and a graphics primitive

return "in-side primitive"

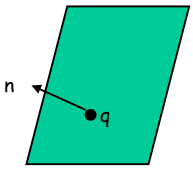


primitives to clip

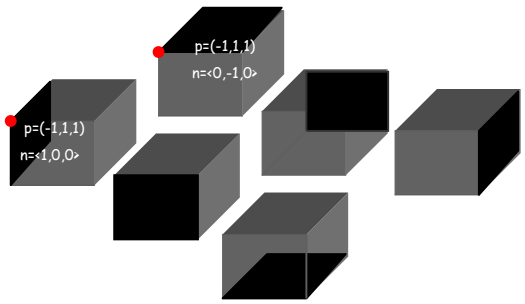
- vertex
- line segment
- polygon

convenient description of bounding plane

1. point on plane q
2. inward-pointing normal n



bounding planes of canonical view volume



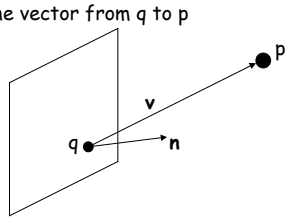
clipping algorithms

- **vertex**
- line segment
- polygon

vertex clipping

p is in with respect to the clipping plane iff $\mathbf{n} \bullet \mathbf{v} \geq 0$ where

- **n** is the inward facing normal
- **v** is the vector from q to p

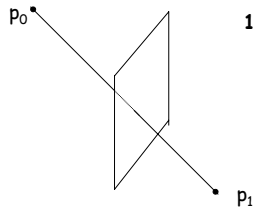


clipping algorithm

- vertex
- **line segment**
- polygon

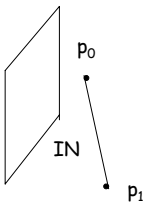
line segment clipping

use test for vertex clipping



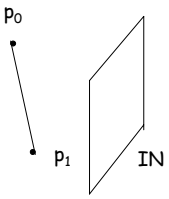
1. **Classify endpoints p_o & p_1 as in or out**

line segment clipping



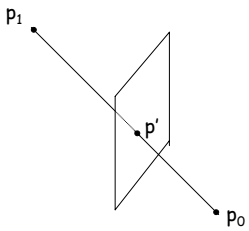
Case p_o & p_1 in:
return (p_0, p_1)

line segment clipping



Case p_o & p_1 out:
return null

line segment clipping



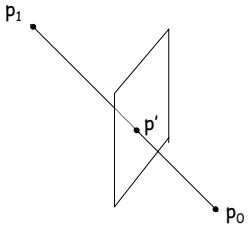
Case p_o in & p_1 out:
return (p_0,p')

Case: p_o out & p_1 in:
return (p',p_1)

do you know how to compute p'?

what should happen to w component?

line segment clipping



color at p':

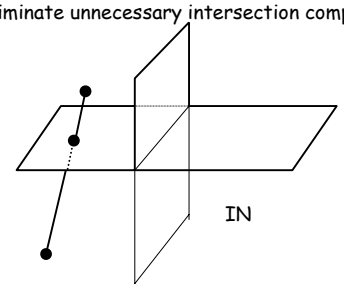
we'll come back to this when we talk about color models

exercise

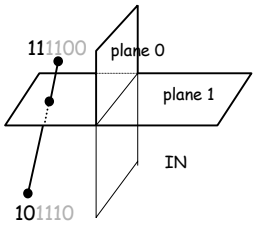
- clip the line with endpoints (-10,-10,-11) and (2,2,1) using the following order of bounding planes:
  - near
  - far
  - left
  - right
  - top
  - bottom
- show the endpoints at the beginning of each step
- how many intersection computations did you do? against which planes?

out-code optimization

eliminate unnecessary intersection computations



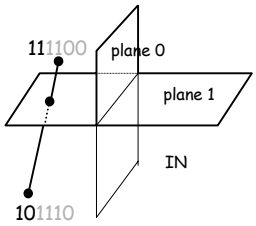
out-code optimization



endpoint p has out-code $b_0b_1...b_5$:

- b_i=0 if p is inside plane i
- b_i=1 else

out-code optimization

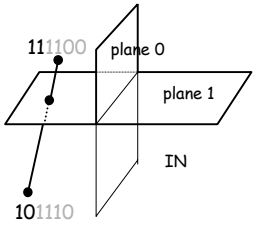


endpoint p has out-code $b_0b_1...b_5$:

- b_i=0 if p is inside plane i
- b_i=1 else

what does it mean if the i^{th} bit of both endpoints is 1?

out-code optimization



endpoint p has out-code $b_0b_1...b_5$:

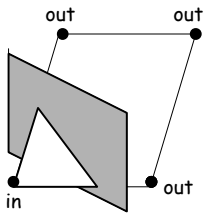
- b_i=0 if p is inside plane i
- b_i=1 else

what does it mean if the i^{th} bit of both endpoints is 0?

clipping algorithm

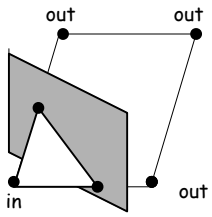
- vertex clipping
- line clipping
- **polygon clipping**

polygon clipping



1. classify vertices

polygon clipping



1. classify vertices
2. compute intersection points of intersecting edges

   &

   write out new polygon

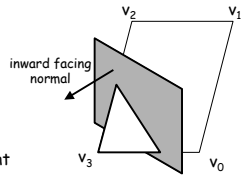
polygon clipping

- if v_0 is in then write v_0
- for i=0…n-1
  - case v_i & v_{i+1} in: write v_{i+1}
  - case v_i & v_{i+1} out: do nothing
  - case v_i in and v_{i+1} out: write intersection point
  - case v_i out and v_{i+1} in: write intersection point and v_{i+1}

indices taken modulo n

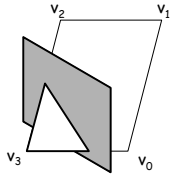
example

if v_0 is in then write v_0
for i=0…3
- case v_i & v_{i+1} in:
  write v_{i+1}
- case v_i & v_{i+1} out:
  do nothing
- case v_i in and v_{i+1} out:
  write intersection point
- case v_i out and v_{i+1} in:
  write intersection point and v_{i+1}



example

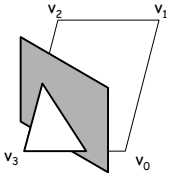
if v_0 is in then write v_0
for i=0…3
- case v_i & v_{i+1} in:
  write v_{i+1}
- case v_i & v_{i+1} out:
  do nothing
- case v_i in and v_{i+1} out:
  write intersection point
- case v_i out and v_{i+1} in:
  write intersection point and v_{i+1}



do nothing

example

i=0
- case v_i & v_{i+1} in:
  write v_{i+1}
- case v_i & v_{i+1} out:
  do nothing
- case v_i in and v_{i+1} out:
  write intersection point
- case v_i out and v_{i+1} in:
  write intersection point and v_{i+1}

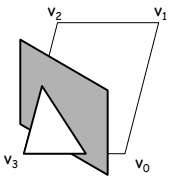


do nothing

example

i=1

- case v_i & v_{i+1} in:
  write v_{i+1}
- case v_i & v_{i+1} out:
  do nothing
- case v_i in and v_{i+1} out:
  write intersection point
- case v_i out and v_{i+1} in:
  write intersection point
  and v_{i+1}

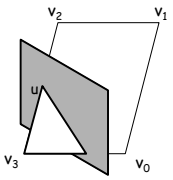


do nothing

example

i=2

- case v_i & v_{i+1} in:
  write v_{i+1}
- case v_i & v_{i+1} out:
  do nothing
- case v_i in and v_{i+1} out:
  write intersection point
- case v_i out and v_{i+1} in:
  write intersection point
  and v_{i+1}



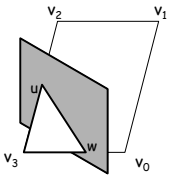
write u, v_3

example

output: u, v_3

i=3

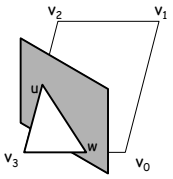
- case v_i & v_{i+1} in:
  write v_{i+1}
- case v_i & v_{i+1} out:
  do nothing
- case v_i in and v_{i+1} out:
  write intersection point
- case v_i out and v_{i+1} in:
  write intersection point
  and v_{i+1}



write w

example

output: u, v_3, w



exercise

- clip the triangle with vertices (-10,0,0), (0,0,0), and (0,10,0) using the following order of bounding planes
  - near (team 1)
  - far (team 2)
  - left (team 3)
  - top (team 1)
  - bottom (team 2)
  - right (team 3)
- each team should write the vertices after each of its steps on the board