CS174A Lecture 9

Announcements & Reminders

- *Midterm: Oct 29*
- *Midterm study guide posted in Piazza*
- *Team project proposals due (first draft): Oct 31*
- *Team project proposals due (final version): Nov 5*
- *Project #3 assigned in Piazza/Github*

TA Session This Friday

- ***Team project***
  - First draft of proposal due: 10/31/19
  - What's expected in the proposal
  - Still looking for teammates? Resolve this Friday
- ***Project assignment #3***
- ***Midterm review***

Jonathan's office hours: Friday 10-11 AM, additional office hours next week before midterm

Yunqi Guo: Office hours Tuesday 9-11 AM

Last Lecture Recap

- ***Spaces:***
  - Model space
  - Object/world space
  - Eye/camera space
  - Screen space
- ***Projections: Orthographic and Perspective***
  - Orthographic and perspective view volumes
  - Canonical (normalized) view volume
- ***Window-to-Viewport Mapping***

Next Up

- *Backface Culling*
- *Geometric Calculations*
- *MIDTERM REVIEW*
- *Hidden Surface Removal*
- *Flat and Smooth Shading*
- *Lighting*

Backface Culling

N = outward normal vector of face
P = a point on face
E = eye vector (from a point on face to eye = E - P)

- In World Space: $N \cdot E > 0$
- In Eye/Camera Space: $N \cdot (-P) > 0$ or $N \cdot P < 0$
- In Projection Space (after perspective division): $N_z < 0$

Geometric Calculations

- **Point in Polygon Test**

i. Semi-infinite ray
   ($y_1 > y_0$ and $y_2 \leq y_0$) or ($y_1 \leq y_0$ and $y_2 > y_0$) where y_0 is the middle vertex of 3 consecutive vertices

ii. Angle summation
   If directed angle sum = 0, then outside, else inside

- **Normal Vector**

i. 3 consecutive vertices (convex vertices): find cross product

ii. Summation method
   $(\sum(y_i - yj)(z_i + zj), \sum(zi - zj)(xi + xj), \sum(xi - xj)(yi + yj))$
   where j = (i+1) mod n; n = total number of vertices

- **Plane Equation**

i. Surface normal and distance from origin
   $n_x x + n_y y + n_z z = d$

ii. 3 points on plane
   $n_x(x - x_i) + n_y(y - y_i) + n_z(z - z_i) = 0$

Geometric Calculations (Contd)

- **On-Line Test**

  P is on P_1P_2 means $\frac{x - x_1}{y - y_1} = \frac{x_2 - x_1}{y_2 - y_1}$

  If $T_{1,2}(P) = (x - x_1)(y_2 - y_1) - (x_2 - x_1)(y - y_1)$

  if +ve, P is on the right; if -ve, P is on the left

- **Edge-Edge Intersection**

  P_1 and P_2 are on opposite sides of line defined by P_3P_4) and

  P_3 and P_4 are on opposite sides of line defined by P_1P_2

  Equivalently, check for intersection:

  $(T_{1,2}(P_3) \cdot T_{1,2}(P_4) < 0)$ and $(T_{3,4}(P_1) \cdot T_{3,4}(P_2) < 0)$

Geometric Calculations (Contd)

- **Collinearity Test**

  t = distance from point P to line P_1P_2
  θ = angle between P_1P and P_1P_2

  $t = |P_1P|\sin\theta = \frac{|P_1P||P_1P_2|sin\theta}{|P_1P_2|} = \frac{|P_1P \text{ X } P_1P_2|}{|P_1P_2|}$

  if $t < \epsilon$, P is considered to be on P_1P_2

Midterm Review

- *Only students registered in the course may take this exam*
- *Exam is closed book, closed notes, closed electronics*
- *Unless explicitly specified, you don't have to multiply matrices*
- *No points are deducted for wrong answers*
- *I will NOT ask anything that I've not covered in class*
- *Midterm carries 100 points*

Chapter 1: Graphics Systems & Models

- *What are the 4 elements of computer graphics?*
- *Examples of procedural animation: physics-based, behavioral*
- *Diff between random scan (calligraphic) & raster output devices*
- *Diff between interlaced and non-interlaced devices*
- *Diff between single and double buffering*
- *Memory space needed by a frame buffer*
- *Max time to read pixel from memory at a certain refresh rate*
- *Book Exercises: 1.8 - 1.11*

Points and Vectors

- *Vector operations, properties, inverse, etc.*
- *Find new point based on initial point and direction of vectors*
- *Dot products, special cases*
- *Cross products*
- *Parametric equations of line and plane*
- *What is the diff between affine combinations and convex combination of points?*
- *Find point on an edge based on different values of α_1 and α_2; which is affine, which is convex?*

Chapter 2.4.1: Polygons

- *What is tessellation and triangulation? Difference between them*
- *Provide the full index structure of a simple polyhedron*
- *Two problems with concave polygons: finding outward normals and determining if a point is inside or outside a polygon*
- *Give 3 reasons why triangles are preferred polys in graphics hardware*
- *Book exercises: 2.11-2.14, 2.18-2.19*

Chapter 4: Transformations

- *Properties of affine combinations*
- *Properties of rigid body transformations*
- *Translation, scaling, rotation, shear, mirror matrices*
- *Prove using HMs that 2 consecutive transformations are commutative*
- *How to rotate a point about a random point?*
- *How to rotate about a random vector, using sequence of rotations or changes of basis/frames?*

Geometric Calculations

- *Point in polygon test for convex/concave polys: semi-infinite ray, angle summation*
- *Normal vector calculations: 3 consecutive CCW vertices, summation method*
- *Plane equations: 3 points in a plane, surface normal + distance from origin*
- *On-line test*
- *Edge-edge intersections*
- *Collinearity test*

Chapter 5: Viewing & HSR

- *What params are needed to form eye/camera matrix?*
- *What params are needed to form orth or pers proj matrix?*
- *Transformations from projection matrices to normalized forms*
- *Aspect ratio*
- *Normalized window to viewport mapping*
- *What is back face culling? How do you do this in world space, in eye space and in normalized projection space?*