Midterm Exam

Fundamentals of Computer Graphics (COMP 557)
Tues. Oct. 14, 2008
Professor Michael Langer

The exam consists of 7 questions. There are a total of 20 points.

1. **(4 points)**

   Let $p_0 = (1,1,9)$, $p_1 = (3,1,15)$, $p_2 = (1,4,15)$ define a triangle within a plane

   $$Ax + By + Cz + D = 0.$$

   (a) Compute the coefficients A, B, C, D of the plane. Hint: first compute the surface normal.

   (b) Consider a ray from the origin and in direction $(1,1,7)$. Where does this ray intersect the plane?

2. **(4 points)**

   Consider a 2D image space whose points are represented in homogeneous coordinates by (wx, wy, w). For each of the two transformations below, give a product of 3×3 matrices that performs this transformation.

   (a) Rotate the scene by θ degrees clockwise around the point $(x, y) = (2, 3)$, that is, this point is not moved but all other points are moved.

   (b) Scale and translate a rectangle that has opposite corners $(1,4)$ and $(3,5)$ to a rectangle that has opposite corners $(-1,0)$ and $(8,6)$.

3. **(2 points)**

   What are the Cohen-Sutherland outcodes for clipping a line in (x, y) space? Sketch an example of a line segment that can be neither trivially accepted, nor rejected. What are the outcodes of its endpoints *prior to clipping* ? (You do not need to clip the line.)

4. **(2 points)**

   What is a depth buffer, and how it is used in hidden surface removal?

5. **(3 points)**

(a) Write the ellipsoid

$$(x-3)^2 + y^2 + 4z^2 = 20,$$

in the form $\mathbf{x}^T\mathbf{Q}\mathbf{x} = 0$ where $\mathbf{x}^T = (x, y, z, 1)$.

(b) What is the equation of this ellipsoid after it has undergone a projective transformation to the view volume between planes $z = -1$ and $z = -8$.

Hint: It is sufficient for you to write your answer as a product of matrices and vectors. One of these matrices should be of the form:

$$\mathbf{M} = \begin{bmatrix} f_0 & 0 & 0 & 0 \\ 0 & f_0 & 0 & 0 \\ 0 & 0 & f_0 + f_1 & -f_0 f_1 \\ 0 & 0 & 1 & 0 \end{bmatrix}.$$

6. **(3 points)**

In class I discussed how object bounding volumes could be used for efficient ray casting.

(a) Briefly explain the basic idea. You do *not* need to discuss the recursive (i.e. hierarchical) aspect of the method that I presented in class.

(b) Suppose we wished to draw a sequence of images (an animation) in which one of the objects is moving and changing shape from frame to frame. How could the bounding volume method be used for this situation?

7. **(2 points)**

How would you obtain a degree 4 polynomial

$$p(x) = ax^4 + bx^3 + cx^2 + dx + e$$

with given values $p(0), p(1), p(2), p(3), p(4)$?

Hint: use the method discussed in the class on cubic curves.