Interactive Computer Graphics Mid-term Exam, 22 Nov. ,2017

1. (15%) According to your homework 1:
   (a) (5%) Describe the computer graphics pipeline.
   (b) (4%) What is vertex shader and what is fragment shader, what's the relationships and differences between them.
   (c) (3%) What's the cons and pros of using indices when drawing a triangle.
   (d) (3%) There is a points list [(1,1,1), (0,0,1), (1,0,1)], is it facing the camera at (0, 0, -5) or not? Please explain.

2. (5 %) What is your term project for this semester? What are the technical difficulties involved in the project? (You can refer to the project listing).

3. (8 %) Suppose the camera is at the (0,0,0) pointing at (0, 0, -1), the up vector is (0, 1, 0). Find the 4x4 transformation that transform the camera to the position (1, 1, 1), pointing at (1,0,1), and setting the up vector to be (0, 0, -1).

4. (6 %) How to render fake shadows using modified homework #1 Phong shading. (For example, suppose there is only a cube on the floor, and the light is on the upside of the cube)

5. (12%) Remember that in our course, our professor once shot a laser beam through his ear as an example. He wanted to show that light can penetrate our flesh.
   (a) (4%) Can Whitted's recursive ray tracing algorithm handle such effects? Why?
   (b) (8%) Refer to the rendering equation. Given the human flesh, considering its complex structures, how to model it correctly, and please explain your method.

6. (15%) A normal vector $\hat{n}$ is defined to be a unit vector that is perpendicular to a given surface. For example, in the three-dimensional Euclidean space, the normal vector of a triangle ABC defined by three points A, B and C can be obtained with $(\overrightarrow{AB} \times \overrightarrow{AC})/||\overrightarrow{AB} \times \overrightarrow{AC}||$. Please answer the following questions:
   (a) (10 %)
      Given a normal vector $\hat{n} = [n_x, n_y, n_z]^T$ and a transformation matrix M containing some translation, rotation, and uniform scaling effects:

$$M = \begin{bmatrix} a_{00} & a_{01} & a_{02} & a_{03} \\ a_{10} & a_{11} & a_{12} & a_{13} \\ a_{20} & a_{21} & a_{22} & a_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

How would you obtain the normal vector $\hat{n}'$ which is the result of transforming $\hat{n}$ by M? Express your solution in mathematical form.

(b) (5 %)

Tom, a naughty boy, likes to see 3-D objects deform in some strange ways. He now adds a non-uniform scaling effect to the transformation matrix M. Is your answer to (a) still correct? If not, briefly explain why.

7. **(10%)**

   (a) Please describe briefly about the types of perspective projection using vanishing points. (3%)

   (b) The following picture is a part of the 清明上河圖, a famous Chinese painting. Would you please discuss about the projection method the painter 張擇(北宋) has used. What are the advantages about this method? Which part is difficult in computing according to your proposed method? (7%)

8. **(10%)** In 2D, a rotation transformation by angle can be specified as a series of shear transformation matrices. Give these matrices, or if it can't be done, prove it.

9. **(10%)** (a) (3%) Painter's algorithm draws polygons from back to front. Give an example where painter's algorithm fails.

   (b) (7%) BSP tree is an algorithm to address the problem painter's algorithm faces. Construct the BSP tree for the following figure. Use face 1 as the root. (c)

What is the display sequence if the eye is placed in the position before face 3 and 2, but at the back of face 5.
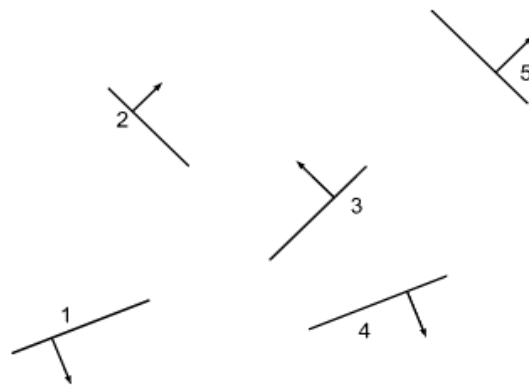
10. Curves and surfaces. **(9%)**

   If we have four control points for the Bezier curve. P1 (1, 2, 4), P2 (3, 8, 6), P3 (6, 6, 4), P4 (8, 2, 2).

(a) (6%) In order to draw this curve, we split it by half. What are the new control points of the two split curves? (Please give exact numbers).

(b) (3%) To design airplane wings, which kind of curve should be used? Bezier curve or B-splines? Why?   (please give short answer).