CS4388 / CS 5388 Midterm Examination October 19, 2020

Due: 10/20/2020 @11:55 pm

Instructions

- This is a take home midterm. It is open book, notes, and online resources.
- Show all the details of your work and carefully explain the way you have solved problems. Failure to comply with this requirement will automatically and deterministically place you on a list of students that have to meet me during office hours and explain their solution, your temporary grade will be 0.
- You can answer in soft form or scan extremely legible written answers.
- Please attach the Midterm form with your name and student id to your answer sheets.
- Please submit all your work including scratch papers and write your name on every paper you submit
- Please make and document reasonable assumptions
- If you are asked to write an Open-GL program snippet, then please only provide the essential parts/modules of the program. In any case the snippet should include the parameters of the projection transformation required.
- **Graduate students have to solve all the questions including questions / sections with bold font.** Undergraduate students are exempt from questions/sections with bold font.
- Use the last digit of your Texas State student id to figure your individual parameters (from Table 1). Note that the parameters are used as vectors and/or as vertices/points depending on the questions. For example if your student id is 12345678, the use 8 as an entry to table and use the parameters:

	u_x	u_y	u_z	v_x	v_y	v_z	w_x	w_y	w_z	a	b	c	d
8	7	5	3	4	4	4	5	7	3	7	4	9	8

Grading

85 → 85 + 9

Your grade is over 100

90 = 90/100; 100=100/100 110=110/100

Please try to provide only the information needed and all the info needed

Questions

1. (30%) Consider the attached picture of a class template. It is desired to produce a computer-generated image of the heads of the students occupying the class. Assume that the classroom is a box with the dimensions $(-a \le x \le a, -b \le y \le b, -c \le z \le c)$ and the point $(a, b, c, 1)$ is at the picture ceiling. Initially, the camera is at $(0,0,0,1)$. The camera, as well as the teacher are "looking" at the $-Z$ direction.

   Without using the 'gluLookat()' function, and using only 'glRotatef()', 'glTranslatef()', and 'glScalef()' write a program snippet that sets a perspective view and places the camera at a point in the center of the ceiling where it can "see" the entire set of heads of the classroom students. You can make reasonable assumptions about the size of students and the distance between desks with respect to $(a, b, \text{ and } c)$

Solution:

```
Use glFrustum() or gluPerspective()  // Projection required
glMatrixMode(GL_MODELVIEW)
glLoadIdentity();
glTranslatef(0.0, b, 0.0);
glRotatef(90.0, -1.0, 0.0, 0.0)
```

2. Consider the points $u = (u_x, u_y, 0, 1)$, $v = (v_x, v_y, 0, 1)$, and $w = (w_x, w_y, 0, 1)$
   a. (10%) Provide the explicit and implicit equation of the line ($\overline{vw}$).
   b. (10%) Provide the parametric equation of the line ($\overline{uv}$).
   c. (10%) Assuming that your parameter is named α ($0 \leq \alpha \leq 1$), find the point that lies on the line and corresponds to the value $\alpha = \frac{\boldsymbol{d}}{\mathbf{10}}$.
   d. (5%) Define the vector $\bar{x} = u - v$, the vector $\bar{y} = w - v$, and the vector $\bar{z} = \bar{x} + \bar{y}$ in homogeneous coordinates.

   Solution:

   Explicit: $y = mx + b$; $m = (w_y - v_y)/(w_x - v_x)$

   To find b use $y - v_y = m(x - v_x)$

   Implicit $y - mx - b = 0$ (in midterm ~~ax + by +c =0~~ was not accepted~~)~~

   B. Parametric

   $x(\alpha) = \alpha u_x + (1 - \alpha)v_x$

   $y(\alpha) = \alpha u_y + (1 - \alpha)v_y$

   c.

   Substitute a = d/10 above

   d.

   $x = [u_x - v_x, u_y - v_y, u_z - v_z, 0]^T$

   $y = [w_x - v_x, w_y - v_y, w_z - v_z, 0]^T$

   $z = [u_x - 2v_x + w_x, u_y - 2v_y + w_y, u_z - 2v_z + w_z, 0]^T$

3. (15%) Write a program snippet that accepts the coordinates of the vertices of a rectangle centered around the origin, with edges that are parallel to the X and Y axes, and with aspect ratioW and converts it into a rectangle centered around the origin with aspect ratio of $\frac{1}{\mathrm{W}}$. The program has to figure W from the given points. You MUST use glScalef(), "just" calculating the new location of vertices is not acceptable.

   Solution:

   Several options including:

   - Load identity and rotate by 90 or -90 around z.
   - Load identity and scale by $(1/w, w, 1)$ $(1/w\text{^}2, 1, 1)$ $(1, W\text{^}2, 1)$
   - ~~Scale (1/w, 1/w, NA)~~

4. (20%) Let $p = 1/a$ (where ‘a’ is your parameter) and let $q = 1 - p$. Consider an OpenGL program for drawing the function $y = f(k) = p \times q^{k-1}$, where $1 \leq k$ is a given integer.

   a. Write an OGL program snippet that plots the function in the range $[1 \leq k < 10 \times c]$ (‘×’ means multiplication).

Solution:

Use glOrtho(0, 10c+1, p*q+1, -1, -1 -1) // max of p*q =1/4

Think about the appropriate camera location

for (x=1; x == k; x++) // some did x+=0.1 which is OK

glVertex (x, pq^(x-1)

Geometric distribution, When:

p=q=1/2 y= $(1/2)^k$ ➔ .5 .25 .125 → Golomb distribution

   b. **Specify the components of a single matrix that scales the plot by d with a fixed point $(c,\ a,\ b, 1)$.**

CTM has some initial value
glTranslatef(c, a, b) CTM ← CTM * T
glscalef(d, d,1,) CTM ← CTM * S
glTranslatef(-c, -a, -b) CTM ← CTM * T^{-1}

CTM ← CTM *T * S * T^{-1} the question asks to find a single matrix for T * S *T^{-1}

Intuitively Multiple the translatef(-c, -a, -b) by scalef(d, d, 1) by translatef(c, a, b)
Practically Multiple the translatef(c, a, b) by scalef(d, d, 1) by translatef(-c, -a, -b)

Figure 1 A class template.

Table 1: Individual parameters

	u_x	u_y	u_z	v_x	v_y	v_z	w_x	w_y	w_z	a	b	c	d
0	2	2	4	7	3	7	3	6	4	2	5	5	4
1	4	8	6	3	8	3	5	6	8	3	7	6	5
2	7	9	8	2	7	6	6	5	7	4	5	7	4
3	5	4	2	2	3	5	2	8	9	7	6	6	3
4	8	9	6	7	4	7	6	4	4	4	8	7	2
5	3	5	2	3	4	5	5	2	6	9	3	2	2
6	5	8	7	6	2	3	3	6	7	3	9	7	7
7	4	1	7	2	6	7	5	8	3	2	9	4	6
8	7	5	3	4	4	4	5	7	3	7	4	9	8
9	6	5	4	6	8	4	3	6	4	5	4	6	7