Assesment 1: Invitation card to the 2024 XJTLU Graduation Ceremony

Module Title	**Computer Graphics**
Module Code	**CPT205**
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Degree Program :	**Information and computing science**

1. Introduction

The purpose of this assessment is to create a two-dimensional (2D) card for the 2024 XJTLU graduation ceremony invitation. According to the requirements, the project uses only the "freeglut" library, MS VC++ and the OpenGL environment to design cards that are 1000 pixels wide and 600 pixels high.

The design concept of this greeting card is based on the theme of "Treasure House of Knowledge" and contains many elements and graphics with learning symbolism. Primarily, the main color of the card is blue, which is the color of XJTLU's emblem. In addition, the greeting card also included some silhouettes of XJTLU's academic buildings. Furthermore, the project adds keyboard and mouse interactions taught in lab sessions, which can trigger different animations.

This assignment uses several techniques in computer graphics that may lead to better results for the visuals in this project. For instance, this project uses Anti-Aliasing technique to reduces the jagged edges of the graphical object and makes the graphics look smoother and more realistic [1]. According to research [2], Bézier curves are widely used to create smooth curves and surfaces as well as to control the shape of graphical objects. Therefore, the direction and curvature of the bends of the curve are determined by setting control points in this experiment.

2. Design and implementation

2.1 External design of the invitation

The cover of this greeting card mimics the shape of invitations and envelopes. To make the cover more eye-catching and layered, different shades of blue were used as fills for the different corners through the "GL_POLYGON" function. The invitation uses the "GL_LINE" function to mimic the design of envelope and the "2024 XJTLU Graduation Ceremony Invitation" was written on the bottom half of the invitation using the self-defined function. Figure 1 shows the appearance of the invitation.

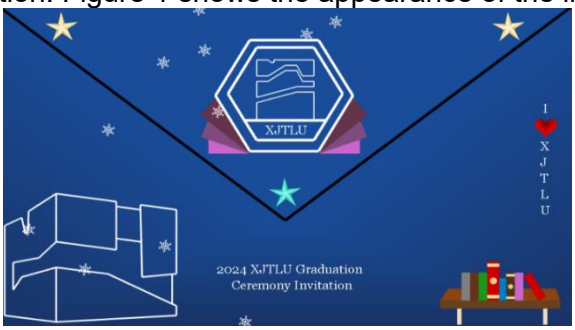

Figure1: External of the invitation

2.2 Interior design of the invitation

The internal background of the invitation is in light blue, with two red ribbons and spinning stars in the top left and top right corners. Besides, there is an elliptical round table at the bottom of the invitation. The parametric equations which define the ellipse are as follows, $(x_0,\ y_0)$ is the point on the arc of the ellipse, (cx, cy) is the center of the ellipse, and a and b are the long and short axes of the ellipse respectively.

$$x_0 = cx + \mathrm{acos}(t)$$
$$y_0 = cy + \mathrm{bsin}(t)$$

The unfolded book on the elliptical table was drawn using the drawing modes "GL_LINE_STRIP" and "GL_LINES" in OpenGL, then using the self-defined functions taught on the lab in Cpt205 to write a letter to the graduation message to the graduates. Figure 2 shows the overall effect of the interior of the invitation.

Figure 2: Interior of the invitation

2.3 Design of the architect

The design of this logo is inspired by the center building of XJTLU University, here "GL_LINE_LOOP" is utilized to depict the front view of the center building. In addition, the XJTLU character is labeled at the bottom of the building using the self-defined function named "drawString()".

On the periphery of the logo, two equal-scaled hexagons are moved into place by "glTranslatef" and "glScale" then encircle the "CB". The sides of the hexagons are also decorated using triangles of different colors. Figure 3 shows more details.

Figure 3: Design of logo

2.4 Design of figure

Center building: The design of the building is mainly inspired by XJTLU's library,

also known as the center building, which is the most suitable place for studying in the whole XJTLU. In order to better present the three-dimensional structure of the library instead of the front view like the logo, I drew the side view of the library with "GL_LINE_LOOP" in the bottom left corner of the greeting card. Moreover, to make the image of the library look fuller, I set the width of the library border to "3.0", as shown is figure 4.

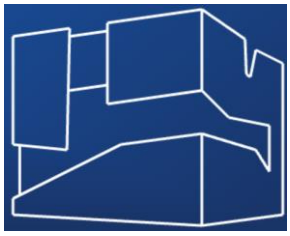

Figure 4: Building

Figure 5: Doctor hat

Docter's hat: In addition to simple polygons mentioned above, the tassels for the Doctor's Hat are generated by applying the Bezier Curve algorithm, as shown in figure 5. Bezier curves uses control points to define the magnitude and direction of curve bending [3]. The following example uses two control points, (x, y) is along the points on the curve, P0 and P3 are the vertex of the line, P1 and P2 are the control points of the curve.

$$x = (1-t)^3 P_{x0} + 3(1-t)^2 \mathrm{t} P_{x1} + 3(1-t)t^2 P_{x2} + t^3 P_{x3}$$
$$y = (1-t)^3 P_{y0} + 3(1-t)^2 \mathrm{t} P_{y1} + 3(1-t)t^2 P_{y2} + t^3 P_{y3}$$

Moreover, we added a small circle to the doctor's hat. This experiment uses parametric equations to fill and plot a circle, where (X, Y) denotes the points on the circle, r denotes the radius of the circle and (x, y) is the center of circle.

$$\mathrm{X} = rx + \cos(t)$$
$$\mathrm{Y} = ry + \sin(t)$$

The color of the circle is adjusted by adding the fluctuations of the cosine function to the original color, thus giving the circle a gradient and shadow effect. C is the function "glColor3f" that controls the color of a single channel, and C will keep increasing with iterations to make the circle brighter.

$$\mathrm{C} = r + 0.1 \times \cos(t)$$

Slogan: "I LOVE XJTLU" is the famous slogan of XJTLU, so we use the custom function "drawString()" to write the characters and then replace "LOVE" with the heart. According to the equation, (x,y) is the point on the edge of the love heart, then fill the love heart with red color according to the parameter equation and "GL_POLYGON". method.

$$x = 16sin^3(t)$$
$$y = 13\cos(t) - 5\cos(2t) - 2\cos(3t) - \cos(4t)$$

Bookshelf: The design of the bookshelf uses different depths of brown to give a three-dimensional effect, with books of different colors on top of the shelves, and books of different sizes placed in different positions on the shelves through "glTranslatef", "glRotatef" and "glScalef".

Figure 6: Slogan

Figure 7: Bookshelf

3. Animation and interaction design

There are four main animations in this experiment, all of which are realized using timers in OpenGL. The desired animation effect can be achieved by setting the translation and rotation angle of the object inside the timer.

3.1 Animation design

Star: In this experiment, we cleverly used the "GL_POLYGON" function and gradient colors to fill a quadrilateral. We then use the "glRotatef" function to convert it to a pentagram shape. All the pentagrams in the invitation are dynamic, after triggering the "StarTimer()" in the main function, all the pentagrams will be triggered every 16 milliseconds (about 60 frames per second) to achieve a constant rotation effect.

Snow: The snowflake inside this experiment incorporated two timers, the timer responsible for the rotation and the timer responsible for the fall. Both timer refreshes are triggered every 16 milliseconds. The snowflake will start rotating and falling at the same time when triggered by "glutTimerFunc".

Figure 8: Star

Figure 9: Snow

Additionally, we used the "rand()" function to randomly generate 20 snowflakes from the top on a 1000 pixel by 600 pixel screen. Once the snowflake dropped to the bottom of the invitation, the system automatically generated a new snowflake.

3.2 Interaction design

Keyboard interaction: The keyboard interaction is responsible for managing the movement of the invitation exterior and the graphic attached to the exterior. For this

experiment, the "V" cutout on the exterior was used as the dividing line, with graphics above the dividing line moving upwards and graphics below the dividing line moving downwards. The following are the interactive effects corresponding to different letters:

Press[K/k]: Open the invitation.
Press[S/s]: Stop the invitation from expanding (Press [K/k] to restart).

Mouse Interaction: Fireworks will shoot out from the bottom left and right corners of the invitation by clicking on the left mouse button. After that, two red dots will rise to the middle of the invitation, and then different colored fireworks set by the custom method "setColor()" will be launched in all directions. Figure 10 shows the fireworks rising and Figure 11 shows the moment they explode.

Figure 10: Firework

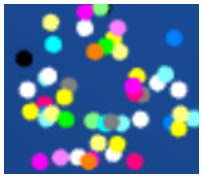

Figure 11: Firework

4. Conclusion

The task is to design an invitation card for the graduation ceremony of XJTU in 2024, which includes different patterns and contains elements characteristic of XJTLU. However, the invitation card did not involve too many interactive effects and animations to make the code look more intuitive. Besides, almost all the code responsible for drawing the graphics is placed in a function starting with "draw" and calling "display()". There are some limitations to this task, such as the possibility of adding more interactions and also optimizing the animations to make the cards look more realistic and aesthetic.

Reference：

[1] P. P. Tanner, P. Jolicoeur, W. B. Cowan, K. Booth, and F. D. Fishman, “Antialiasing: A technique for smoothing jagged lines on a computer graphics image—an implementation on the Amiga,” Behavior Research Methods, Instruments, & Computers, vol. 21, no. 1, pp. 59–66, Jan. 1989. doi:10.3758/bf03203871

[2] X.-A. Han, Y. Ma, and X. Huang, “A novel generalization of Bézier curve and surface,” Journal of Computational and Applied Mathematics, vol. 217, no. 1, pp. 180–193, Jul. 2008. doi:10.1016/j.cam.2007.06.027

[3] Author links open overlay panelJiwen Zhang et al., “C-Bézier curves and surfaces,” Graphical Models and Image Processing, https://www.sciencedirect.com/science/article/pii/S1077316999904902 (accessed Oct. 25, 2023).