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# **Assessment 1 - 2D Modelling Project**

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# 1 Introduction

This assignment delves into the intricate realm of 2-dimensional modelling, which synthesizes the theoretical graphic knowledge ranged from the first lecture to date, encompassing essential concepts such as geometry, transformation and viewing. Furthermore, another objective is to enhance the programming techniques, specifically in OpenGL and C++. An invitation card to the 2024 XJTLU Graduation Ceremony should be generated as the eventual result of the endeavor, which aims to provide a memorable experience for the impending graduates, marking their final significant event at the institution.

To increase the engagement of participants, loads of interactions were considered and applied during the design and coding phrase. Moreover, modular programming and necessary comments were employed and added to guarantee the codes readability.

## 2 Instruction

- Upon clicking on the running button on the top of the debugging interface, it will display the designed card with a graduation cap in the left of the screen and five yellow blank boxes revolving around the lower part of it.
- To carry out the following phases, relevant interaction is indispensable. Specifically, there are two patterns regarding it in this project, namely mouse and keyboard.



(a) Not Clicking on Boxes



(b) Clicking on Boxes

Figure 1: Mouse Interaction

- For mouse-clicking, it can accomplish two kinds of activities:
  1. Firstly, a **left-button-click** on anywhere but boxes will result in a 72-degree-clockwise rotation for the cap.
  2. Moreover, if the left-click locates at five **blank frames**, not only the revolution will occur, but also corresponding letter will appear in each box: from left to right are "X", "J", "T", "L", "U" respectively. Figure 1 above visualizes these procedures.

- For keyboard-inputting, it aims to fulfil just one mission: shifting the positions of letters. Specifically, when in the English mode, after clicking a box, using four keys: "w", "s", "a", "d" can make the selected item move up, down, left, and right. Figure 2 below exhibits an example of this.



Figure 2: Keyboard Interaction

- Following the above steps, it will generate the eventual invitation card with a university abbreviation which has a self-defined position.

### 3 Features

- **Geometry:** The piece utilizes graphics primitives to produce diverse objects:
  1. Background: The sky and grass are two main components of the rectangular background, with a gradual change in the combination of blue and green.
  2. Clouds: The basic shape of clouds is the circle. Specifically, the function `cloud()`, which defines the initial location and color of the object, calls the method `drawCircle()` to generate five circles to yield a cloud.
  3. Trees and Flowers: Fundamental figures for plants are rectangles, triangles and circles. Likewise, the `tree()` and `flower()` adjust relevant arguments to obtain transformed geometric shapes, for example, translated, rotated and scaled circles, to make sure they are similar enough with real objects.
  4. Building: Central Building (CB) is regarded as one of the most significant architectures of XJTLU. To highlight the theme of the work: the invitation to XJTLU commencement, the `house()` posits the simplified CB which is represented by polygons and red line strips in the right middle of the screen.
  5. Cap: Similarly, on the other side the method `caps()` creates a polygonal bachelor hat which is a symbol of graduation. Relevant interactions with it will be explained in the next stage.

6. Boxes: Revolving around the cap, there are five pure yellow square boxes that are defined by the struct `Box` and designed for further interactions.
  7. Stars: The function `drawFiveStar()` draws two twinkling and rotating stars which stand on both sides of the "Congratulations" to create a delightful atmosphere.
  8. Plane: The paper plane produced by the `plane()` will follow the specific route (a Bezier curve) to symbolize the process of the overall university journey: from freshmen to graduates.
- **Character:** "Comic Sans", a typeface resembling the handwritten script, is employed to render all texts in this card through `selectFont()` and `drawString()`, which seeks to establish a relaxing and amiable atmosphere for the graduation ceremony. Viewed from left, upper contents deliver congratulatory messages dedicated to the graduates while the lower section of characters serves as an invitation. Likewise, as the top right quadrant of the screen illustrates the temporal and locational details of events, the bottom exhibits the time span of individual's collegiate experience.

Figure 3 below shows an initial window, which encompasses the combination of all abovementioned elements.



Figure 3: Initial Window

## 4 Design Techniques

- **Viewing:** Orthogonal projection is indispensable for the achievement of 2D modelling task in OpenGL. Specifically in this work, `GL_PROJECTION` is initialized to the matrix mode for further projection function `gluOrtho2D()`, which makes it available for OpenGL to map the 3D World Coordinates to 2D Window Coordinates.
- **Transformation:** Upon applying the orthographic projection, the argument is reset to `GL_MODELVIEW` to render all necessary objects. To guarantee the desired position and realistic shape of

elements, transformations such as translation, rotation and scaling are crucial. For example, when painting flowers, `glRotated()`, `glTranslated()` and `glScaled()` are applied to get the center surrounded by elliptic petals, which makes them more close to objects in reality.

- **Interaction:** As the Instruction section mentioned above, two kinds of interactions are designed. The `mouse()` is set up to rotate the cap and render the five hidden letters (X, J, T, L, U) visible. When clicking their respective boxes sequentially, the rotation and appearance are implemented simultaneously. The objective is to immerse participants in finishing the entire XJTLU learning life. Specifically, the manifestation of the last character coincides with the completion of a circular revolution by the cap, symbolizing the accomplishment of educational journey. Moreover, the `keyboard()` enables graduates to relocate frames to their expected places.
- **Parametric Curve:** Bezier Curve is a sort of the design curve. Its shape depends on control points that are declared in the vector `myPoints`. Another vector `bezierPoint` is created to store the points on the curve, which is calculated by the De Casteljau algorithm, following the below formula:

$$b_i^{(k)} = (1-t) \cdot b_i^{(k-1)} + t \cdot b_{i+1}^{(k-1)}$$

- **Animation:** To enhance the vividness of the piece, animation plays an essential role, which rely on the time callback function `onTimer()`. For instance, `onTimer()` defines incremental values for the variables `starRotate` and `cloudMove` between certain timing intervals, which controls the rotating twinkling stars and drifting clouds. Additionally, the plane will traverse along the predefined Bezier Curve through periodic translations that are contingent upon the coordinates of the current point `curCnt` declared in `onTimer()`.

The eventual result generated by the combination of all features listed and graphic techniques abovementioned is shown in figure 4 below.



Figure 4: Final Card

Here marks the culmination of the 2D modelling project report.