CPT205 – Assessment 2
Car-based Road Transport System

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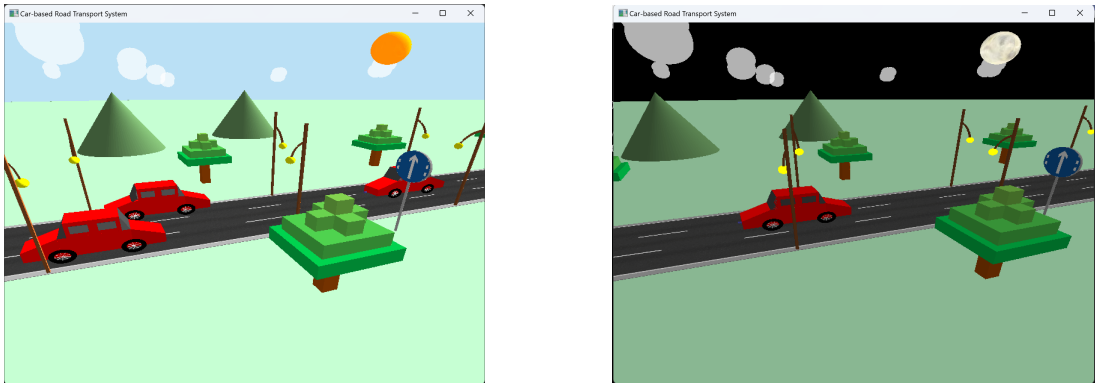
1 Introduction

The primary concentration of this assessment is the conscientious design and implementation of a three-dimensional (3D) scene, using related OpenGL libraries in freeglut and manifesting an amalgamation of static and dynamic components. As Figure 1 shows, it was implemented in a car-based transport system under two different driving modes during the day and night. The central imperative lies in the execution of graphics techniques, encompassing the creation of geometric entities, hierarchical modeling, transformations, and nuanced considerations of viewing, projection, lighting, materials, texture mapping, animation, and user interactions. They will be introduced in detail next.



(a) Day mode with several cars (b) Night mode with one car

Figure 1: Overall rendering of Car-based Road Transport System

2 Detail description of system

The scene depicts the car transportation system during the day and night. In this scene, cars, the road, trees, lamps, mountains, a signpost, clouds, and the sun during the day or moon at night are specifically presented.

2.1 Car

The entire car was created by combining the body, windows, ignition system, and wheels.

2.1.1 Body

To draw the entire car body, the front and back body sections were drawn using combinations of quads, while the bottom, top, and middle sections were drawn using solid cubes. To guarantee appropriate shading, normals were also specified for each face of the front and back bodies.

2.1.2 Windows

Windows can be separated into two categories: side windows and front and back windows. The front and back windows of the car were quads combined. Furthermore, each face defines normals and sets the color. Solid cubes were utilized to draw a side window, scaled to the appropriate dimensions.

2.1.3 Ignition system

The ignition system on the left rear of the car was drawn by a blue solid cylinder being rotated.

2.1.4 wheel

The black tire was made of a solid torus, and the circular shape on the wheel rim was made using line striping and trigonometric functions. Finally, different wheel components were integrated to draw all four wheels in proper locations.

2.2 Road

The road was a scaled cube.

2.3 Tree

2.3.1 Trunk

The brown trunk is drawn utilizing a solid cube with scaling and translation to achieve the desired size and position.

2.3.2 Leaves

The green leaves are arranged in multiple layers, each created with solid cubes and different scaling factors. The colors of the leaves are varied for each layer to create a realistic appearance.

2.4 Lamps

The lamp structure includes a yellow spherical light bulb, and the lamp is mounted on a brown pillar, created using a cube primitive. Additionally, a bracket made with a Bezier curve provides support for the light bulbs.

2.5 mountains

The mountains were created as a green cone in a place far from the road, providing a natural and organic appearance.

2.6 Signpost

The signpost consists of a cylindrical post and an additional cylindrical structure attached horizontally to the top of the post to support the noticeboard.

2.7 clouds

The white clouds drawing employs stencil testing and blending techniques, allowing the overlapping spheres to blend their colors to simulate a cloudy sky. A series of spheres are drawn with translations to create overlapping cloud-like structures.

2.8 Sun and moon

They are all in the upper right corner of the initial screen, drawn from spheres. Moreover, they represent day and night, respectively.

3 Graphics techniques

3.1 Creation of geometry

Almost all the objects that appear in the scene were created by different geometry, such as cubes, cylinders, spheres, and cones.

3.2 Hierarchical modelling

Several objects, including the wheels, windows of the car, clouds, lamps, the signpost, and trees, used hierarchical modeling, such as parent-child relationships.

3.3 Transformations

Almost all objects transformed such as translation, rotation, and scaling. Moreover, matrix transformation of model, view, and projection matrices was also used.

3.4 Viewing and projection

The scene was set up with different camera views, which can be controlled by keyboard interactions and mouse wheels.

3.5 Lighting and materials

The scene was designed to work with two light sources for day and night, allowing for a dynamic adjustment of lighting conditions in the graphics scene. It also takes into account ambient, diffuse, and specular components to simulate realistic lighting effects.

Different materials have been set for different objects, one by one. For example, the windows of the car were specular, while the other parts of the car could not be specular. Furthermore, the lamp light bulbs could emit light at night but not during the day. In addition, emitted light from the sun and the moon had distinct hues.

3.6 Texture mapping

Four texture maps were used in this scene to provide realistic appearances. The road is the first, the sun and moon are the second, and the moon is the third. The signpost is the final one.

3.7 Animation

The sun, moon, lamps, trees, signs, mountains, cars, and wheels could animate. Wheels, the sun, and the moon could rotate while the others could translate.

3.8 Interactions

- Keyboard interaction:

Press '**Y**' or '**y**' to adjust the whole scene rotation.

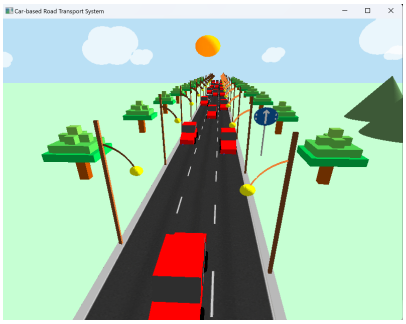
Two interactions in the following only occur when in Single Car Mode:

Press '**L**' or '**l**' to affect the car's offset and change the angle of the car's movement to the left and the wheel angle based on acceleration and direction.

Press '**R**' or '**r**' to affect the car's offset and change the angle of the car's movement to the right and wheel angle based on acceleration and direction.

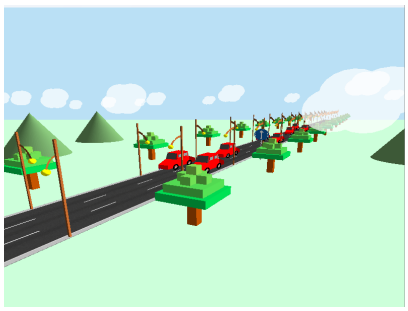
Press '**-**' or '**+**' to control the acceleration of the car (speed down and speed up).

Press '**F**' or '**f**' to decrease the viewing angle.

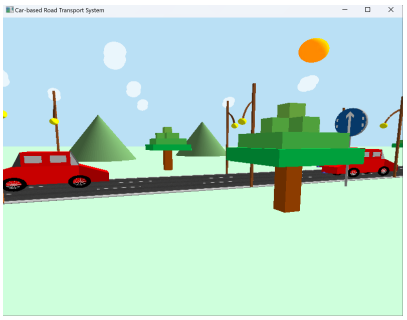


(a) Press 'y', scene rotates.

(b)Press 'W', car's color changes.



(c)Press 'F', viewing angle changes



(d)Press 'D', camera's position is down

(e) Press 'l', the car moves to the left and the wheels rotate to the left.

Figure 2: Some keyboard interactions example

Press '**D**' or '**d**' and '**U**' or '**u**' to adjust the camera's Y-position (down and up).

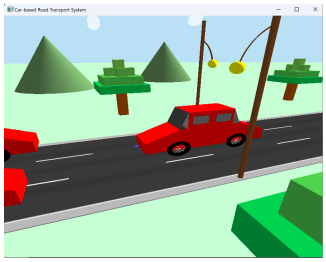
Press '**W**' or '**w**' and **S**' or '**s**' to change the car's color by incrementally adjusting the blue and green components of the car's body color.

Press '**R**' or '**r**' to incrementally increase the sun's and moon's angles. They could not rotate so fast exactly. But in this scene, they were assumed to rotate.

- Mouse interactions:

Scroll Up: Zoom in.

Scroll Down: Zoom out. The zoom extent was ensured to stay within a reasonable range.



(a) Scroll up to zoom in

(b) Scroll down to zoom out

Figure 3: Examples of mouse interactions

Right Click: Choose different modes.

Car Driving Mode:

1 "Many Cars Mode": Sets the system to a mode where there are multiple cars.

2 "A Car Mode": Sets the system to a mode with a single car that can change the driving lane as the offset.

(a) Car Driving Mode

(b) Light Mode

Figure 4: Two different modes

Light Mode:

1 "Day Mode": Sets the scene to day mode.

2 "Night Mode": Sets the scene to night mode.

4 Conlusion

In summary, this assessment delved into the application of theoretical concepts in computer graphics through the creation of a three-dimensional (3D) scene of a car-based transport system. As witnessed in the amalgamation of static and dynamic elements and graphics techniques within the scene, we have presented a tangible representation of our scholarly pursuits in the field of computer graphics through the creation of this 3D scene.