

Three-Dimensional Visualization and Animation

Technical report

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1 Overall project structure

Whole game is managed by a GameManager class. GameManager is initialized from main.cpp file. First, we initialize GLUT, GLEW, and create a window. Functions of the GameManager class such as keyboard input, mouse handling, screen resizing and rendering are registered as GLUT callbacks.

All of the game elements inherit from the base GameObject class. This class stores the position of the object and defines several virtual functions (such as render or update). Objects which are dynamic (DynamicGameObject) then override some of the virtual functions in order to add functionality. Other example of this can be the CollidableGameObject which implements collisions. Full GameObject inheritance tree is visualized on the image below.

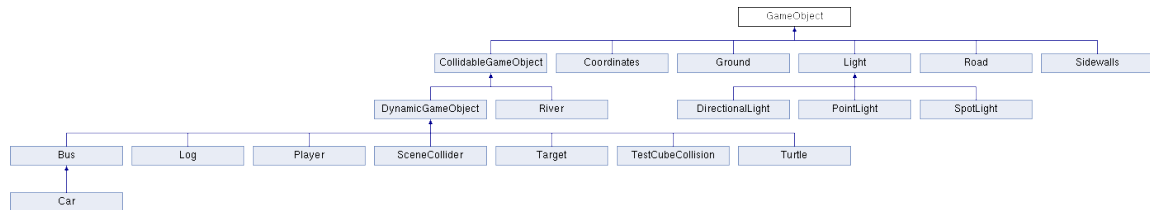


Figure 1: Objects which inherit from the GameObject class.

GameManager class is responsible for both storing and updating all of the GameObjects. All of the objects in the scene are stored in a vector inside the GameManager. When the class is initialized, an init function is called for each of them. This function is responsible for setting up of materials and allocation of all of the meshes for each object. Since all of the meshes are stored in a global array, instead of manually typing the meshID's, we utilize a static counter attached to the GameObject class which automatically keeps track of IDs.

Each render pass (automatic callback from GLUT) first all of the physics are updated. All of the GameObject implement an update function. In case of DynamicGameObject, this function is overridden to actually change the position of the GameObject. All of the updates are multiplied by a deltaTime variable in order to preserve the game speed along with varying FPS. After the physics update, we check for collisions between the player and the environment as well as between some of the moving objects in the scene and side colliders. If the GameObject is out of the scene, we respawn it to the other side of the map.

Last step of each render pass is to call render function on all of the GameObjects. This function is responsible for transforming, rotating and scaling of all of the meshes in the game and then sending them into the graphics pipeline. As the player progresses, the game difficulty increases. This is done by multiplying all of the environment's movements by a global multiplier variable.

2 Graphic modeling

All of the game objects are created out of cube meshes with different materials. Busses and cars have animated wheel movements, the turtles dynamically move above and under the water and logs are moving in the water flow.

3 Cameras

All of the Cameras also inherit from the GameObject class. This allows us to easily change their position. User can switch different cameras with keyboard commands. The position of the camera which follows the player is updated from the GameManager class after each physics pass.

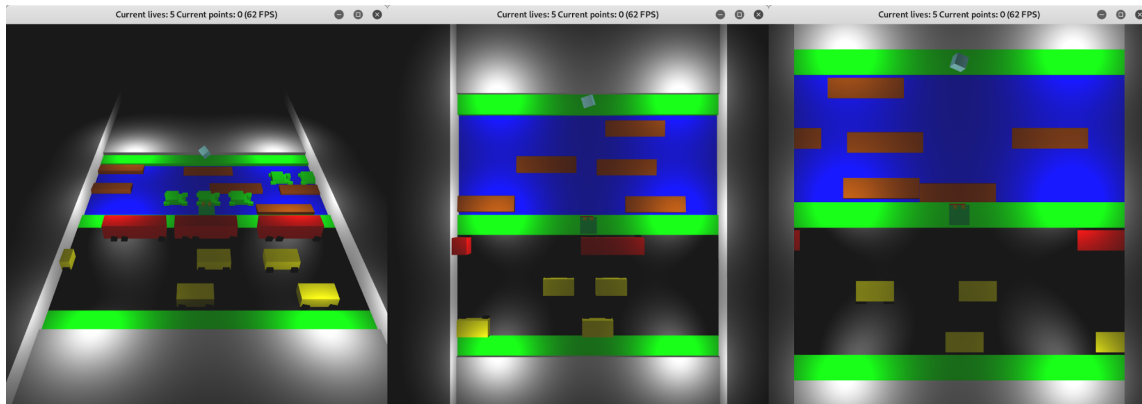


Figure 2: From left to right: perspective moving, perspective fixed and orthogonal camera.

4 Movement of game elements

As mentioned earlier, all of the moving GameObjects inherit from the DynamicGameObject class. This class extends the GameObject class with speed vector. Each physics update, this vector is multiplied by deltaTime and added to the current GameObject's position.

$$\text{position} = \text{position} + \text{deltaTime} \cdot \text{speed}$$

5 Lighting of the scene

All of the lights inherit from the `GameObject` class. The position of the `GameObject` is used as the position of the light. In case of `SpotLight`, we also use another vector to store the direction of the light. All of the positions of lights are passed as individual uniforms into the vertex and later fragment shader. This could be improved with usage of vertex buffer objects, however our solution also works well for a project of this scale.

Based on the state of the light (ON/OFF), all of the colors of fragments are summed in the fragment shader. We used provided code from exercises but modified it for our usecase. We have also consulted the Redbook light chapter in order to implement different types of lights.

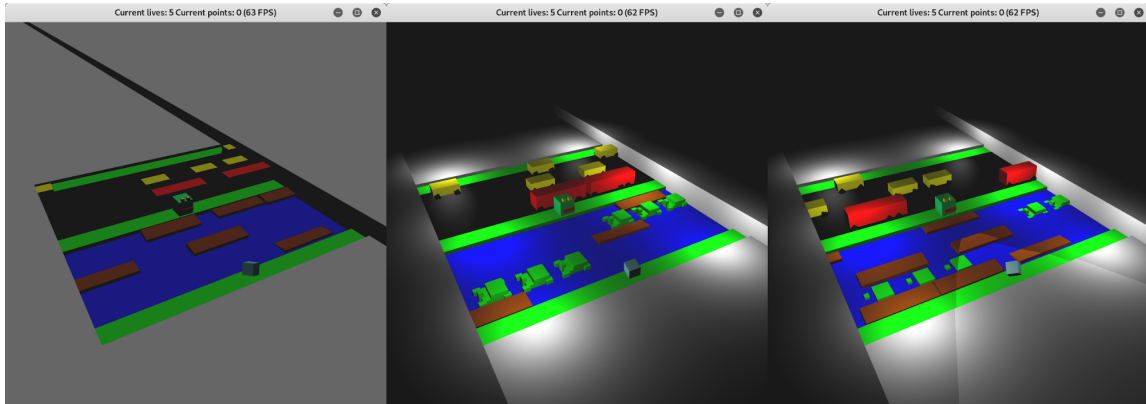


Figure 3: From left to right: directional light, point lights and point lights with spotlight.

6 Collision detection

After each physics update, the collisions are checked by the `GameManager` class. All of the collidable `GameObjects` contain a bounding box and also a function to check for collisions between them. Since we do not need to check collisions between all of the `GameObjects` within the scene, we can save resources and need to only perform $O(n)$ comparisons instead of $O(n^2)$.

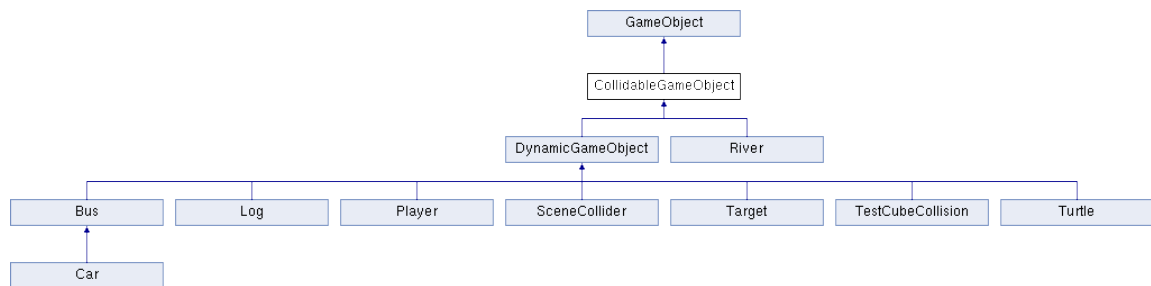


Figure 4: All of the collidable game objects in the game.

In order to check what's beneath of the player, the player's `GameObject` contains 2 colliders. One on the top for collisions with cars and busses and one beneath to check whether the player is standing on a log or a turtle.

7 Texture mapping

Due to time constraints of some of our team members and also because of inability to work on the project by one of the team members for personal reasons, texture mapping was not implemented. We hope to change this before the next iteration of the project.

8 HUD (lives, score, reset, pause)

Limited time resources also led us only to utilizing the game window's title to communicate with the player. This is done by accessing the GLUT's window handle and passing a string into it. Game window therefore shows the information about the current lives, score and provides the user with instructions when the player dies.



Figure 5: Example of the implemented HUD.

9 Conclusion

We have implemented a functional prototype of a `Frogger3D` game in `OpenGL`. Matyáš Skalický is responsible for the overall architecture, physics and lights. Mykhaylo Marfeychuk worked on collision detections, object modeling, respawning and animation. Bernardo Eichler was not able to contribute to this assignment due to personal reasons. We hope that this will be not the case of following assignments.