Computer Graphics assignment 2020

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Setup

The project was written using Python 3.7.4 and requires the Python runtime installed and following packages:

- glfw
- PyGLM
- PyOpenGL
- glm
- numpy
- pywavefront

To install them at once, you can call

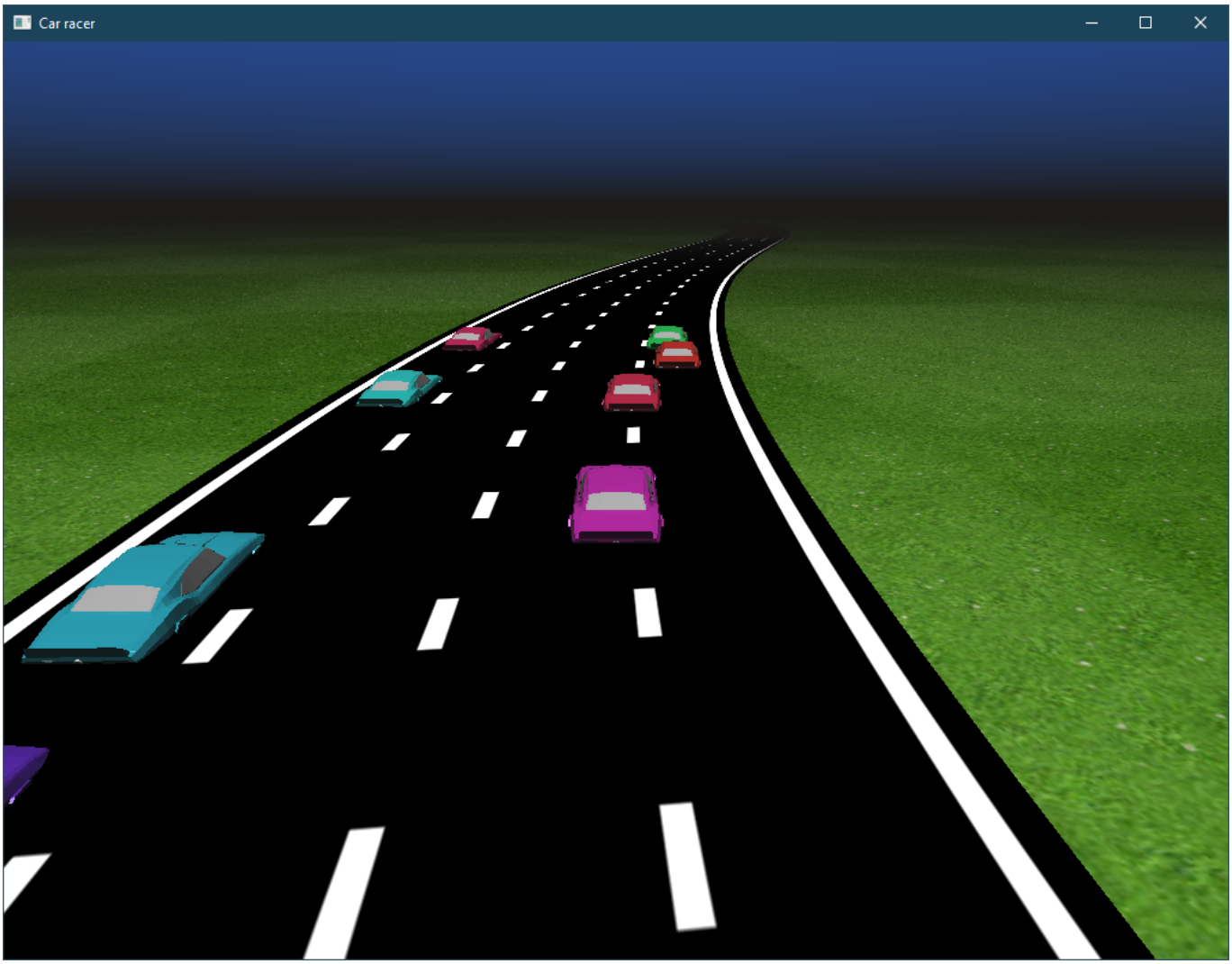
```
pip install glfw PyGLM PyOpenGL glm numpy pywavefront
```

Running

To run the application, execute `python3 main.py` in the project root folder.

The application consists of some cars racing along an infinite track, switching lanes, overtaking and lagging behind.
The user can use the `c` button to switch between the available camera angles.

Screenshot



Tweaking

The file `main.py` contains variables that can be changed to tweak the simulation. The following table summarizes these variables.

Name	Meaning	Default value
num_cars	Number of cars	13
max_y	Maximum distance between first and last car	14
lanes	Number of lanes	4
arc_len	The length of traced track	0.15
car_size	Scaling of cars	0.03
car_speed	Speed of cars	0.3
lane_width	The width of lanes	0.2

Modules

The code is structured into python modules. Below is a description of each module.

camera: Defines a typical 3D camera class, `camera`, that can calculate the view and projection matrices using `glm`.

cube: Defines a single class, `cube` that displays a cube, using the car shaders. It was used for development, before the model loader and is now unused.

draw: Stores data needed for drawing a model with Phong shading. Namely the Vertex Array Object, the vertex count and the shading colors.

envbox: Renders a huge skybox using the envbox shaders. Also loads the grass texture using `PIL.Image` and uploads it to the GPU.

main: The heart of the application. Opens a window using `glfw`, creates and manages car states and uses these states to render cars at their correct position. Also manages an `envbox`, and a `road` object, and renders using a `camera`. This file contains variables that can be tweaked (see above).

model: Loads an obj model using `pywavefront` and uploads every mesh in the scene defined by the obj, creating a VAO for each of them. This way the colors of the object can be changed.

road: Creates a large 2xN grid with integer coordinates, that will be rendered with the road shaders.

Shaders

The real graphics happen in the shaders. I employed some tricks to make the simulation easier to code. All shaders are written against the GLSL 3.3 core standard. The shader files are located in the `shaders` folder.

car: The car shader renders the given geometry using the Phong shading model.

envbox: This is a more complex shader than the car shader. It calculates a ray direction from the camera and if that direction is above the horizon, it mixes three colors to simulate sky color.
If the direction points below the horizon, then the 2D point on plane Y=0 and view ray is determined and its x and z coordinates are used to sample the grass texture, resulting in the environment around the road.
A checkerboard pattern is applied to the grass to make it look less repeating.
Fog is applied to the grass.

road: This shader's input space is the 2xN integer lattice, which is transformed using the same function that `main.py` uses to displace cars, to form the shape of the road.
The integer lattice can be treated as a UV coordinate and thus enables us to create procedural stripes. these are also antialiased.

Acknowledgement

The car model and the grass texture are free assets acquired from the sources:

- car: https://www.freelancer.hu/contest/Toon-grass-texture-k-tileable-1437066-byentry-24207508?ngsw-bypass=&w=f
- grass: https://free3d.com/3d-model/chevrolet-camaro-ss-coupe-373476.html