CPT205 Computer Graphics (2020-21)

Assessment 3 – Discussion Questions and 3D Modelling Project

Shen Wang

1824260

Information and Computing Science

2021. 1. 7

PART I. Discussion Questions

Question 1. Briefly describe the graphics pipeline, identify pipeline bottlenecks, and discuss possible ways to tackle the bottlenecks for enhancing the performance from both software (e.g. algorithms) and hardware perspectives.

Q1 Answer:
The graphics pipeline is a model that describes steps to display geometry objects on screen [1]. It can be divided into three conceptual categories: the application stage, the geometry stage and the rasterizer stage.

- The application stage is controlled by software running on CPUs, which prepare and submit the geometry to the geometry stage for rendering.
- The geometry stage operates vertexes and polygons on GPUs, and can be divided into several functional stages: model and view transformation, vertex shading, projection, clipping and screen mapping.
- The rasterizer stage manipulates each pixel on the screen to draw graphics on GPUs. Similarly, it can be divided into: triangle setup, triangle traversal, pixel shading and merging [2].

However, there are bottlenecks in pipeline. Firstly, the graphics pipeline demand of high computational and memory resources. To improve this, it is needed to make sure frame buffer, textures and static vertex buffers fit the video memory. Secondly, there are limitations on CPU. For example, one bottleneck is batching. The performance of CPU can be improved by increasing batch-sizes aggressively. Furthermore, smart but expensive CPU algorithms should be avoided to reduce render load. Thirdly, fragment shader has limitations on GPU. Proper use of fragment shaders can improve its performance [3].

Question 2. Discuss applications of computer graphics incorporating artificial intelligence. This should cover techniques, key issues and possible solutions with directions for future development.

Q2 Answer:
Computer graphics deals with using computer to create images. It is one of the core technologies in digital photography and cell phone and computer displays [4]. Artificial intelligence is the ability of a computer to do tasks that require human intelligence and discernment.

Many technologies in AI, like neural network and deep learning, can be combined with computer graphics technologies to improve the effort and speed of computer graphics processing. For example, manually analysing data and setting parameters to generate realistic scenes requires a lot of debugging but may not realistic enough. However, AI can do better and faster than human on this work. A team in Vienna University used neural network to processing light, which had a satisfying result [5].

A main problem of computer graphics incorporating artificial intelligence is that the AI needs to "learn" how to deal with graphics with large amounts of data and examples, which needs time and patience. In addition, artificial intelligence can also make mistakes, so it still needs to be checked by humans.

In the future, with the development of artificial intelligence, computer graphics will definitely combine AI.

References

[1] “Graphics Pipeline.” Wikipedia.com.
https://en.wikipedia.org/wiki/Graphics_pipeline

[2] A. Gkountis. “Overview of the Graphics Pipeline.” fragmentstorm.com.
http://www.fragmentstorm.com/overview-of-the-graphics-pipeline#the-application-stage
(accessed Mar. 17, 2019).

[3] K. Ashida. (2004). Optimising the Graphics Pipeline [Online].
Available: https://www.nvidia.com/docs/IO/10878/ChinaJoy2004_OptimizationAndTools.pdf

[4] “Computer graphics.” Wikipedia.com.
https://en.wikipedia.org/wiki/Computer_graphics

[5] K. Zsolnai-Fehér, “Gaussian material synthesis,” *ACM Trans. on Graphics*, 2018, doi: 10.1145/3197517.3201307

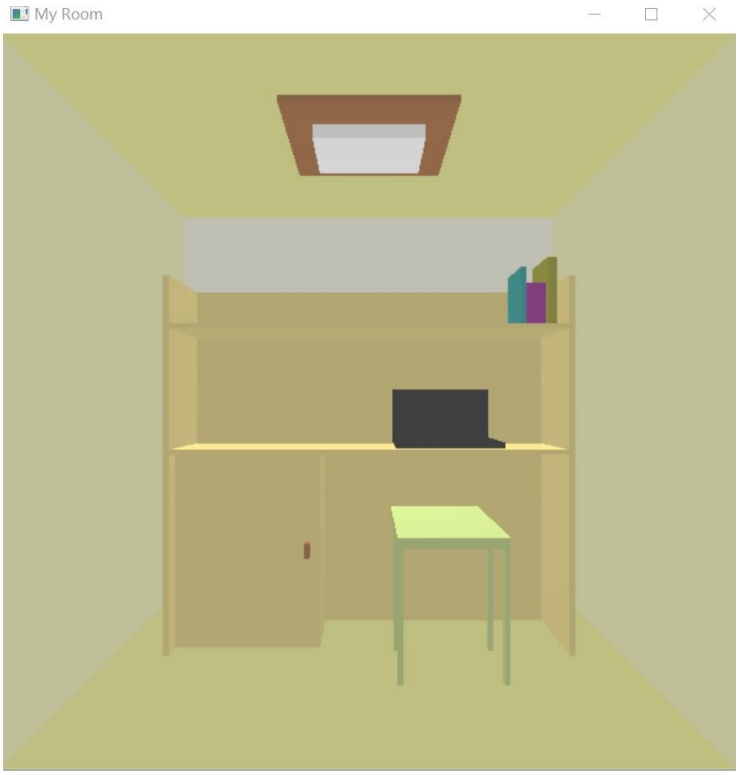
PART II. 3D Modelling Project

An Introduction to 3D Modelling Project

Objective

The objective of the project is to generate a 3D modeling scene of daily life. Computer graphics technologies in CPT205 should be used in this project. For example, hierarchical modelling, transformations, viewing/projection, lighting and materials, texture mapping, animation and interactions and so on.

Design and Features



I create a 3D scene of a room. As the screenshot, it is a scene of a room. The view point is the center of the front of the room.

The walls are 5 3D quads: ceiling, floor, back wall, left wall and right wall.

There is a lamp on the ceiling. The lamp holder is a brown solid cube and the lamp bulb is a white solid cube.

Under the lamp is a table and a chair. The table was propped up by three wooden boards standing on the floor. On the top of the table, there are three books on the right. On the workbench, there is a black laptop computer, which is interactive. Under the workbench, there is a cabinet on the left side with brown handle. The wooden boards, workbench, handle and cabinet are all solid cubes on different positions with different lengths, widths and heights. The books and laptop are also solid cubes with different colors and sizes.

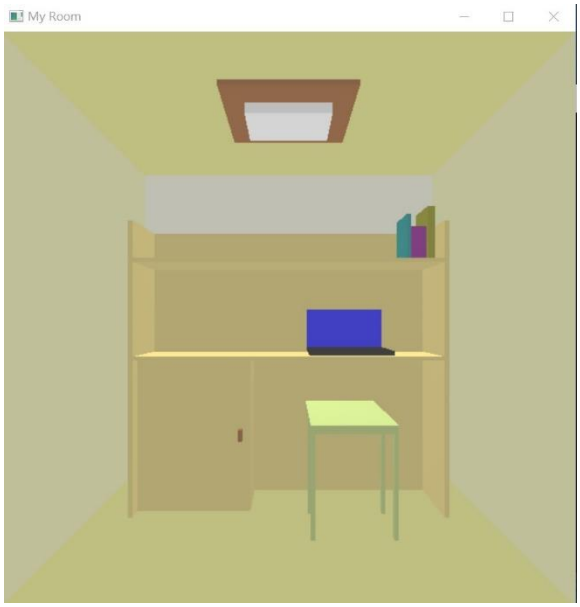
There is a green chair in front of the table. The seat and four legs are solid cubes with the same color.

When creating these solid cubes, glPushMatrix(), glPopMatrix() and glTranslatef() are used to move to different positions. In addition, glScalef() and glutSolidCube() are used to generate solid cubes with different sizes.

There are several interactions. Firstly, the laptop can be started or closed. One of the parameters of the color of the laptop screen is a variable. If the laptop is started, the screen color will gradually change from black to blue. Similarly, the laptop can be closed. Moreover, the light can be turned on or turned off. The

two lights and materials parameters are set before generating the scene. The material parameter is a variable. If the light situation is changed, the material parameter will also be changed.

Instruction



key 1 …… laptop power on

key 2 …… laptop power off

key 3 …… turn on the lamp

key 4 …… turn off the lamp

This is a screenshot of start the laptop.

The following is a screenshot of turn off the light.