Homework 1 - OpenGL Basics

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02/15/2024

Contents

1 Change History

Version: 1.0
Modifier: Isaiah Martinez
Date: 2/15/24
Description of Change: Updated the buffer. Manually adjusted the values within vertices. Homework 1 completed.

Version: 0.5
Modifier: Isaiah Martinez
Date: 2/12/24
Description of Change: Added the logic for colorValue and deltaColor. Logged to the console. Unsure of why triangle colors are not changing, despite colorValue showing differences.

2 Introduction

This document descibes the architecture and design for the first assignment with OpenGL. The objective with this assignment was to create a triangle that oscillates between colored and non-colored.

There are two windows that are created when the program is run: window 1 which contains the triangle, and window 2 which is the console output for the program. Window 2 displays nothing until window 1 is closed.

There is a single major stakeholder:

1. The professor

3 Design Goals

The priorities for the design are as follows:

- The design should minimize complexity
- The design should be conceptually easy to understand
- The design should be easy to modify

4 System Behavior

The use case view is the prime motivator for the System Behavior. This is because the program is simple with no complex components.

The program starts with the triangle filled in, demonstrated by the left triangle in Figure 1, and then progresses onward infinitely until the Escape Key is pressed. The code describing this behavior will be explained further in Section 5. The Use Case diagram can also be seen for further explanation in figure 6 within section 6.

In Figure 1, the right triangle has a white outline and black fill to demonstrate that the triangle exists, but lacks color. When the program is run however, the triangle loses color until it is not visible anymore.

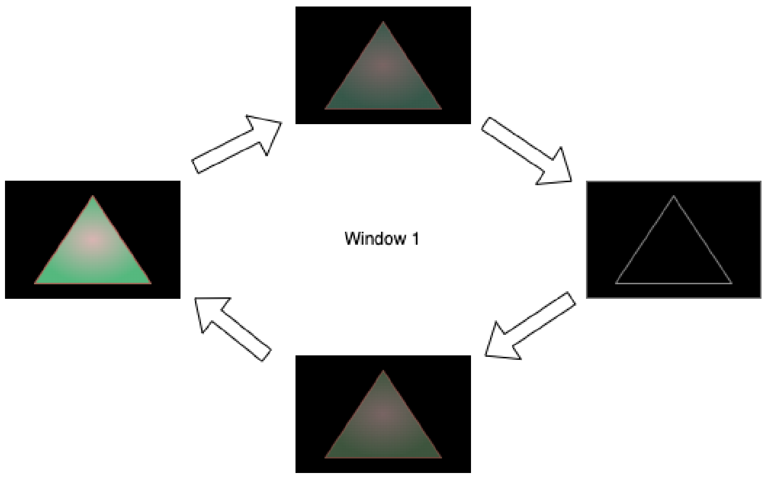


Figure 1: System Behavior for Window 1.

5 Logical View

In this section, the system will be described from a Mid-Level Design View, looking at the code itself. Specifically, we will be looking at the variables and tools used to make the color changing of the triangle work.

5.1 Mid-Level Design

There are several key parts to the code that allow for triangle to be drawn each frame.

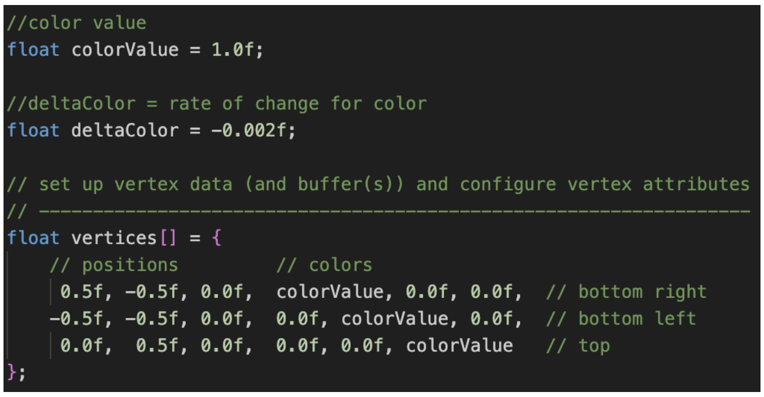
5.1.1 Vertices

The first key part is the vertices variable. This variable is defined as an array with length 18. I utilized 2 variables to help for changing the color later on in the code.

I utilized a variable colorValue to represent the value of the current color for the given vertex. It is initialized to 1.0f to start with a colored triangle, similar to how the demonstration video starts.

Another variable I created was deltaColor which represents the rate of change for colorValue. The use for this variable is explained later on in the render loop.

As seen in Figure 2 below, the array is separated into 2 different sections: the positions of the points to generate the triangle, and the colors associated with that part of the triangle. The ordering is x, y, z for the coordinates, eg. vertices[0] = 0.5f represents x = 0.5 on the cartesian coordinate system. vertices[1] = -0.5f represents y = 0.5 also on the same plane. Notice that there are no points lying outside of the cartesian plane since all z values = 0. The colors represent RGB in order, thus vertices[3] = 1.0f represents the amount of red to apply. vertices[4] and vertices[5] = 0.0f representing no values for Green and Blue respectively. Thus, the overall color of this vertex extending towards the other points of the triangle is red.



```cpp
//color value
float colorValue = 1.0f;

//deltaColor = rate of change for color
float deltaColor = -0.002f;

// set up vertex data (and buffer(s)) and configure vertex attributes
// ------------------------------------------------------------------
float vertices[] = {
    // positions         // colors
     0.5f, -0.5f, 0.0f,  colorValue, 0.0f, 0.0f,  // bottom right
    -0.5f, -0.5f, 0.0f,  0.0f, colorValue, 0.0f,  // bottom left
     0.0f,  0.5f, 0.0f,  0.0f, 0.0f, colorValue   // top
};
```

Figure 2: Important Variables utilized for changing the color of the triangle.

5.1.2 VBO and VAO

Now having described the vertices variable in detail, I will briefly describe another set of key parts of the code: the VBO and VAO.

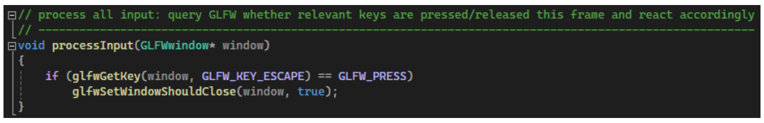
We use a VBO (Vertex Buffer Object) for managing the vertices variable. The VBO is used for storing the vertex data, which in our case would be the position and color. This is then sent to the GPU for fast rendering.

We also utilize a VAO (Vertex Array Object) for changing states of the VBO quickly and easily. This proves useful for adjusting the state of the VBO from one color to the next in an efficient manner.

5.1.3 Render Loop

The final key part of the code is within the render loop.

The first portion worth mentioning is the function given which processes the user input. This function allows for the user to close the program.

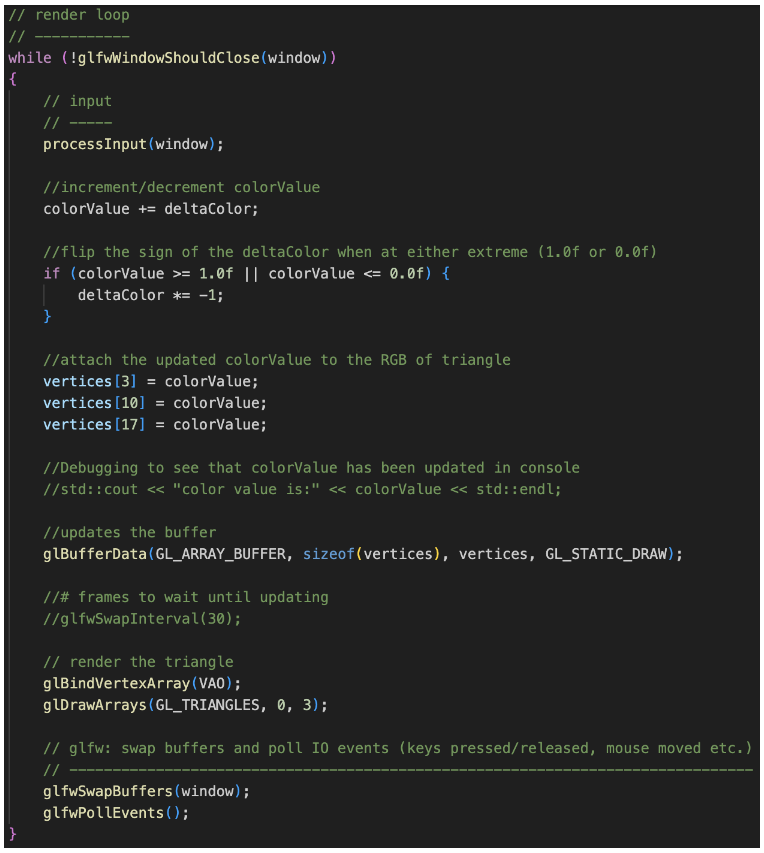


```cpp
// process all input: query GLFW whether relevant keys are pressed/released this frame and react accordingly
// ---------------------------------------------------------------------------------------------------------
void processInput(GLFWwindow* window)
{
    if (glfwGetKey(window, GLFW_KEY_ESCAPE) == GLFW_PRESS)
        glfwSetWindowShouldClose(window, true);
}
```

Figure 3: User Input logic.

Another part of the render loop is the logic used to update the triangle. This is done using the VAO and adjusting the previously mentioned variables colorValue and deltaColor.

First, colorValue is added to deltaColor and subsequently set to the new value. Then, the logic performs a boolean check to see if colorValue has hit or passed either extreme value for the color value possible for the system. These values are 1.0 and 0.0 respectively. If colorValue has reached either extrema or beyond them, then the sign of deltaColor is flipped. This optimization allows for minimal code to be written and succinctly describing the process.



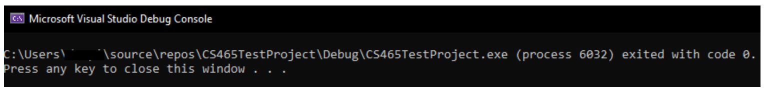
```
// render loop
// -----------
while (!glfwWindowShouldClose(window))
{
    // input
    // -----
    processInput(window);

    //increment/decrement colorValue
    colorValue += deltaColor;

    //flip the sign of the deltaColor when at either extreme (1.0f or 0.0f)
    if (colorValue >= 1.0f || colorValue <= 0.0f) {
        deltaColor *= -1;
    }

    //attach the updated colorValue to the RGB of triangle
    vertices[3] = colorValue;
    vertices[10] = colorValue;
    vertices[17] = colorValue;

    //Debugging to see that colorValue has been updated in console
    //std::cout << "color value is:" << colorValue << std::endl;

    //updates the buffer
    glBufferData(GL_ARRAY_BUFFER, sizeof(vertices), vertices, GL_STATIC_DRAW);

    //# frames to wait until updating
    //glfwSwapInterval(30);

    // render the triangle
    glBindVertexArray(VAO);
    glDrawArrays(GL_TRIANGLES, 0, 3);

    // glfw: swap buffers and poll IO events (keys pressed/released, mouse moved etc.)
    // -------------------------------------------------------------------------------
    glfwSwapBuffers(window);
    glfwPollEvents();
}
```

Figure 4: Render Loop logic.

Afterwards, the newly updated colorValue is attached to the respective color value within the vertices variable. Subsequently, we draw the buffer and utilize the VAO to render the triangle once again.

6 Use Case View

The user has the ability to close window 1 by pressing the Escape key, as seen in Figure 3. After pressing closing window 1, pressing any key allows for window 2 to be closed.



```
C:\Users\[redacted]\source\repos\CS465TestProject\Debug\CS465TestProject.exe (process 6032) exited with code 0.
Press any key to close this window . . .
```

Figure 5: The console used to display that the window may be closed.

The state diagram demonstrating the logic for the windows can be seen in Figure 6 seen below.

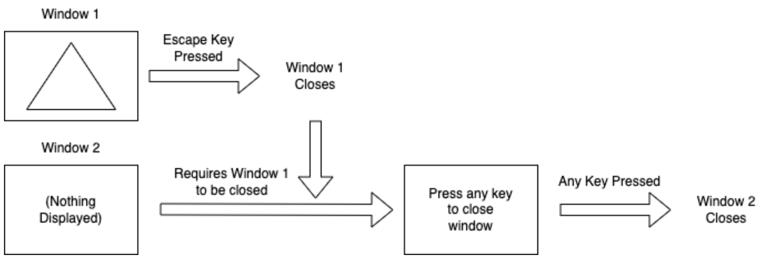


Figure 6: A diagram demonstrating the Use Case Scenario.

7 Reflection

I found the most challenging part of the homework to have the triangle actually change colors. I initially had assigned colorValue with the idea in mind that it would change the color of the triangle, and all I needed to do was update its value. When this proved to not be true, I was confused and logged the values to see that it was in fact changing. When the changes were visible but still no color changes on the triangle were visible I was perplexed. Afterwards, I realized I didn't update the VBO, meaning that the changes weren't being rendered. After adding the line to update the buffer, there were still no changes and I was stumped for a long time. Then I had the idea to manually update the values within vertices to the new value of colorValue. To me this seemed redundant, since vertices was defined with colorValue and I assumed it was dynamically referenced. As it turns out however, this was untrue! Vertices was defined and its values were statically defined, so when I manually input the new values for the color, the code worked.

I would say that I learned that I need to explicitly define changes to all associated parts. Ranging from definitions of variables like in vertices, to changing the values within the variables, and finally updating the buffer to draw the new image.