

Homework 1 - OpenGL Basics

Isaiah Martinez
CSUN
Computer Science Department
isaiah.martinez.891@my.csun.edu

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1 Introduction

This document describes 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 output for the program. Window 2 displays nothing until window 1 is closed.

There is a single major stakeholder:

1. The professor

2 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

3 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 4. The Use Case diagram can also be seen for further explanation in figure 6 within section 5.

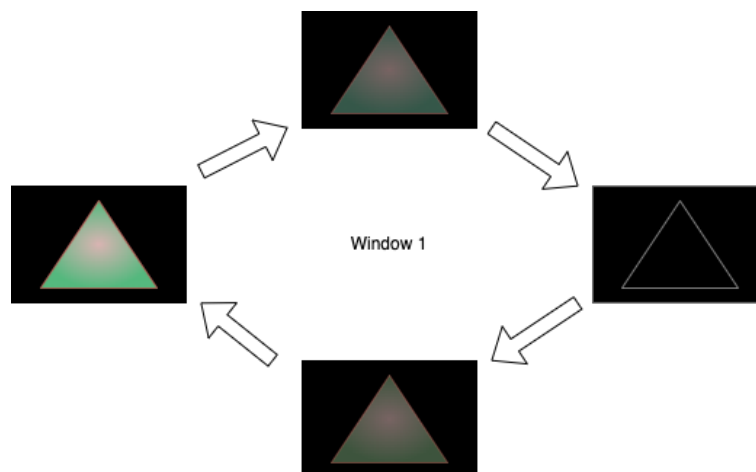


Figure 1: System Behavior for Window 1.

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.

4 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.

4.1 Mid-Level Design

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

4.1.1 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.

```

//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.

4.1.2 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.

4.1.3 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.

```

// 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.

5 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.

```
Microsoft Visual Studio Debug Console
C:\Users\...\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.

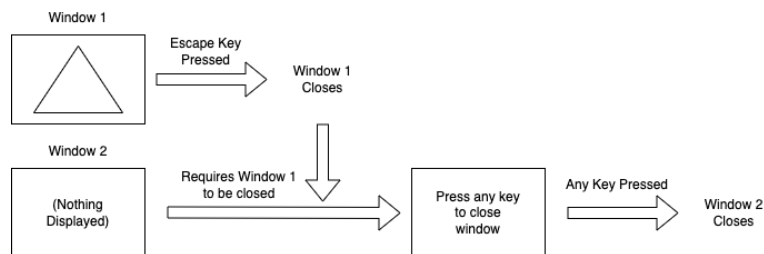


Figure 6: A diagram demonstrating the Use Case Scenario.