Computer Graphics Assignment 1: Basic OpenGL viewer & drawing a hierarchical model

Handed out: April 8, 2019

Due date: 23:59, May 5, 2019 (NO SCORE for late submissions!)

Submit your assignment only through the page of this course at learn.hanyang.ac.kr.

1. Implement a basic OpenGL viewer and show an animation of a hierarchical model using the viewer. This viewer will also be used in future class assignments.

   A. **You have to implement all requirements in a single program. This assignment DOES NOT require each requirement to be a separate program**

2. **Requirements**

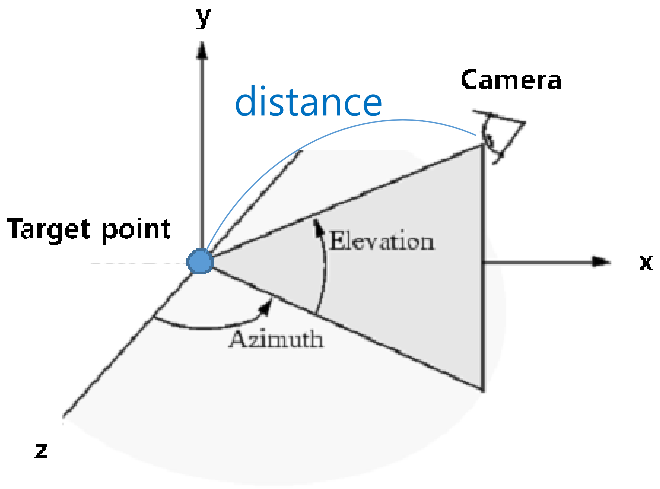
   A. **Manipulate the camera with mouse movement (50 pts)**

      i. Refer the camera manipulation of Blender software.

         1. https://www.blender.org/download/

      ii. The camera of your program should always look at a target point, similar to that of Blender.

         1. Initialize the target point to the origin (0, 0, 0)



         2.

      iii. Provide the following three camera control operations.

1. **Orbit**: Rotate the camera around the target point by changing azimuth / elevation angles. (MMB (mouse middle button) in Blender) **(15 pts)**

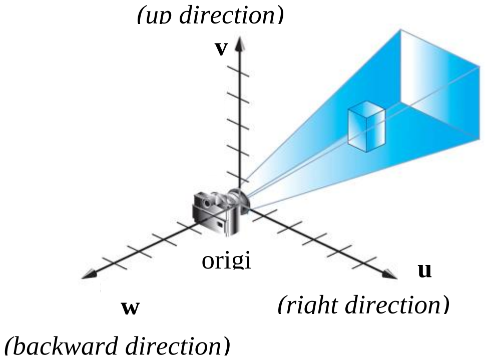
    A. Do not rotate the camera about a vector from the camera to the target point.

2. **Panning**: Move both the target point and camera in left, right, up and down direction of the camera (Shift-MMB in Blender) **(15 pts)**

    A. More specifically, translate both the target point and camera along u axis (left & right) and v axis (up & down) of the camera frame

3. **Zooming**: Move the camera forward toward the target point (zoom in) and backward away from the target point (zoom out) (Ctrl-MMB in Blender) **(15 pts)**

    A. A. More specifically, translate the camera along w axis of the camera frame



B.

4. You MUST use the following mouse movement:

A. Orbit: Click mouse left button & drag

B. Panning: Click mouse right button & drag

C. Zooming: Rotate mouse wheel

D. Using above mouse movements is essential for scoring your assignment, so if you use any other set of mouse movement or keyboard shortcuts for Orbit / Panning / Zooming, you won't get any score for them.

iv. Use perspective projection

v. Draw **a rectangular grid with lines (not polygons) on xz plane** as a reference ground plane (similar to Blender). Choose number of rows and columns, size as you want. **(5 pts)**

B. Create an animating hierarchical model using OpenGL matrix stacks (40 pts).

i. The model should consist of **3D primitives** such as boxes and spheres,

ii. You can use drawCube() and drawSphere() in the last page, or your own drawing functions (which should use only numpy, opengl, glfw).

iii. **DO NOT use glut or glu functions to draw 3D primitives** (e.g., glutSoildBox(), gluSphere(),...) because they generate runtime crashes on some systems (maybe problems of some python bindings, but don't use them anyway).

iv. Because we've not covered *shading* yet, just draw your model in **wireframe mode** by calling the following function at the beginning of your render function:

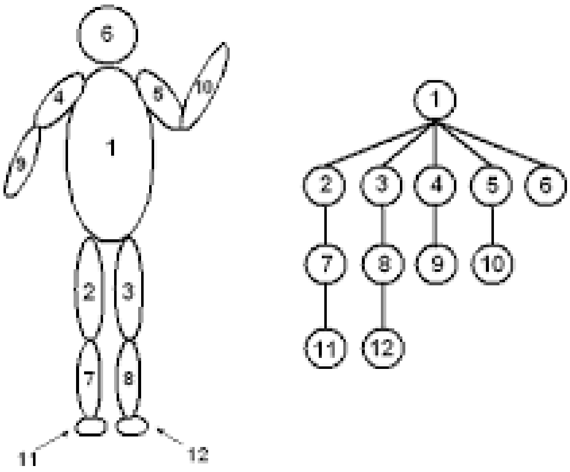
   1. glPolygonMode(GL_FRONT_AND_BACK, GL_LINE) # call this at the beginning of your render function

   2. You can change the color of your wireframe primitives using glColor*().

v. **You should use OpenGL matrix stack** to draw and animate your hierarchical model.

vi. The model should have a **hierarchy of at least 3 levels (20 pts)**.

   1. For example, the following model has a hierarchy of 4 levels.

   2. 

vii. **Animate the model** to show the hierarchical structure **(20 pts)**.

   1. **Make all child body parts move relative to their parent body part.**

      A. In the above example, part 2, 3, 4, 5, 6 should move relative to part 1, part 7 should move relative to part 2, part 11 should move relative to part 7, ... and so on.

   2. You can make any hierarchical system freely. Be creative.

      A. Eg) a hand with fingers bending

B. Eg) a runner with arms and legs swing

3. The model should be **automatically animated without any mouse or keyboard inputs.**

3. Report (10 pts)

A. Submit a report of **at most 2 pages** in docx file format (MS Word). Do not exceed the limit.

B. The report should include:

i. How to run your program

ii. Which requirements you implemented

iii. A few screenshot images of your program

4. Your program should be able to run on systems only with Python 3.5 or later, NumPy, PyOpenGL, glfw. Do not use any other additional python modules.

A. And the window size doesn't need to be (480, 480). Use the larger window that is enough to see the details of the viewer.

5. What you have to submit:

A. **A zip file ([studentID]-class1.zip, e.g., 2017123456-class1.zip)** including

i. **.py files**

1. You can use multiple .py files for this assignment. In this case, explain how to run the program in the report.

ii. **.docx report file**

6. drawCube() and drawSphere() code:

```
# draw a cube of side 2, centered at the origin.
def drawCube():
    glBegin(GL_QUADS)
    glVertex3f( 1.0, 1.0,-1.0)
    glVertex3f(-1.0, 1.0,-1.0)
    glVertex3f(-1.0, 1.0, 1.0)
    glVertex3f( 1.0, 1.0, 1.0)

    glVertex3f( 1.0,-1.0, 1.0)
    glVertex3f(-1.0,-1.0, 1.0)
    glVertex3f(-1.0,-1.0,-1.0)
    glVertex3f( 1.0,-1.0,-1.0)

    glVertex3f( 1.0, 1.0, 1.0)
    glVertex3f(-1.0, 1.0, 1.0)
    glVertex3f(-1.0,-1.0, 1.0)
    glVertex3f( 1.0,-1.0, 1.0)

    glVertex3f( 1.0,-1.0,-1.0)
    glVertex3f(-1.0,-1.0,-1.0)
    glVertex3f(-1.0, 1.0,-1.0)
    glVertex3f( 1.0, 1.0,-1.0)

    glVertex3f(-1.0, 1.0, 1.0)
    glVertex3f(-1.0, 1.0,-1.0)
    glVertex3f(-1.0,-1.0,-1.0)
    glVertex3f(-1.0,-1.0, 1.0)

    glVertex3f( 1.0, 1.0,-1.0)
    glVertex3f( 1.0, 1.0, 1.0)
    glVertex3f( 1.0,-1.0, 1.0)
    glVertex3f( 1.0,-1.0,-1.0)
    glEnd()


# draw a sphere of radius 1, centered at the origin.
# numLats: number of latitude segments
# numLongs: number of longitude segments
def drawSphere(numLats=12, numLongs=12):
    for i in range(0, numLats + 1):
        lat0 = np.pi * (-0.5 + float(float(i - 1) /
float(numLats)))
        z0 = np.sin(lat0)
        zr0 = np.cos(lat0)

        lat1 = np.pi * (-0.5 + float(float(i) / float(numLats)))
        z1 = np.sin(lat1)
        zr1 = np.cos(lat1)

        # Use Quad strips to draw the sphere
        glBegin(GL_QUAD_STRIP)

        for j in range(0, numLongs + 1):
            lng = 2 * np.pi * float(float(j - 1) / float(numLongs))
            x = np.cos(lng)
            y = np.sin(lng)
            glVertex3f(x * zr0, y * zr0, z0)
            glVertex3f(x * zr1, y * zr1, z1)

        glEnd()
```