MSIM 441/541 & ECE 406/506
Computer Graphics & Visualization

Homework Eight

Assigned November 12, Due 12:00 PM November 19

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Overview

This homework covers the lecture on Chapter 5. Please only submit one single file that includes solutions to the tasks specified below.

Tasks

1. Describe the components in a synthetic camera model. What are the characteristics of geometric optics?
   1) Components of synthetic camera model:
      i. Objects
      ii. Viewer or center of project (COP)
      iii. Projectors: lines from objects to COP
      iv. Projection plane
   2) Characteristics of geometric optics:
      i. Projection surface is a plane
      ii. Projectors are straight lines
2. Define the canonical viewing volume.
   1) When projection metric is applied to view space (view space is normalized). Only x- and y-coordinates will be mapped on to screen and z-component is used for depth. $(x, y, z) \in [-1,1]$
3. Calculate the projection matrix corresponding to the following OpenGL command

   glFrustum(–2, 2, –2, 2, 1, 30) = (l, r, b, t, n, f).

$$n = near, f = far, l = left, r = right, t = top, b = bottom$$

$$P = \begin{bmatrix} \frac{2n}{r-l} & 0 & \frac{r+l}{r-l} & 0 \\ 0 & \frac{2n}{t-b} & \frac{t+b}{t-b} & 0 \\ 0 & 0 & -\frac{f+n}{f-n} & -\frac{2fn}{f-n} \\ 0 & 0 & -1 & 0 \end{bmatrix} = \begin{bmatrix} \frac{2}{4} & 0 & 0 & 0 \\ 0 & \frac{2}{4} & 0 & 0 \\ 0 & 0 & -\frac{31}{30} & -2 \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

4. Given the OpenGL command gluLookAt(2, 5, 3, 8, 2, 3, 0, 1, 1). Calculate the direction of positive *z*-axis of the camera coordinate system and the matrix that transforms world coordinates to camera (eye) coordinates.

$$n = eye - at = \begin{bmatrix} -6 \\ 3 \\ 0 \end{bmatrix}, |n| = \begin{bmatrix} -\frac{2}{\sqrt{5}} \\ \frac{1}{\sqrt{5}} \\ 0 \end{bmatrix}, u = v_{up} \times n = \begin{bmatrix} -3 \\ -6 \\ 6 \end{bmatrix}, |u| = \begin{bmatrix} -\frac{1}{3} \\ -\frac{2}{3} \\ \frac{2}{3} \end{bmatrix}$$

$$, v = n \times u = \begin{bmatrix} 18 \\ 36 \\ 45 \end{bmatrix}, |v| = \begin{bmatrix} \frac{2}{2\sqrt{5}} \\ \frac{4}{3\sqrt{5}} \\ \frac{\sqrt{5}}{3} \end{bmatrix}$$

$$\therefore A^{-1} = \begin{bmatrix} -\frac{1}{3} & \frac{2}{3\sqrt{5}} & -\frac{2}{\sqrt{5}} & 2 \\ -\frac{2}{3} & \frac{4}{3\sqrt{5}} & \frac{1}{\sqrt{5}} & 5 \\ \frac{2}{3} & \frac{\sqrt{5}}{3} & 0 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} = \begin{bmatrix} -\frac{1}{3} & -\frac{2}{3} & \frac{2}{3} & 2 \\ \frac{2}{3\sqrt{5}} & \frac{4}{3\sqrt{5}} & \frac{\sqrt{5}}{3} & -\frac{13}{\sqrt{5}} \\ -\frac{2}{\sqrt{5}} & \frac{1}{\sqrt{5}} & 0 & -\frac{1}{\sqrt{5}} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

5. Run the program projection.exe provided by Nate Robin’s tutors, experiment with various parameters, and capture several program windows.

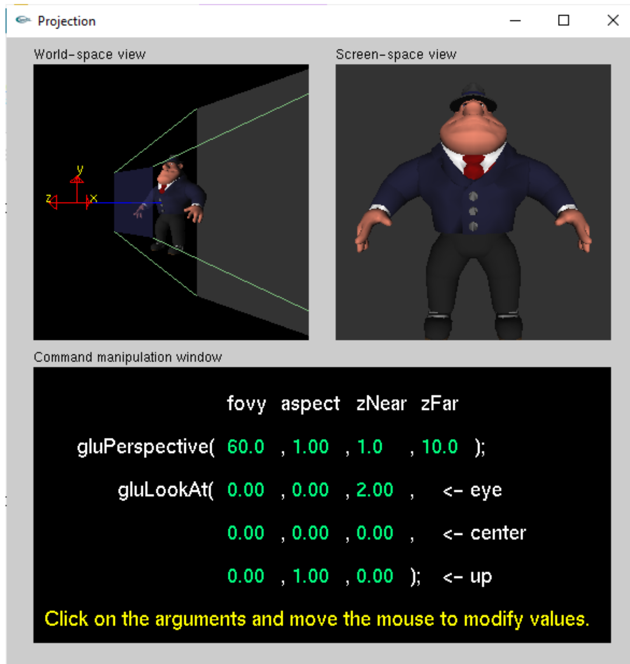

Figure 1. original

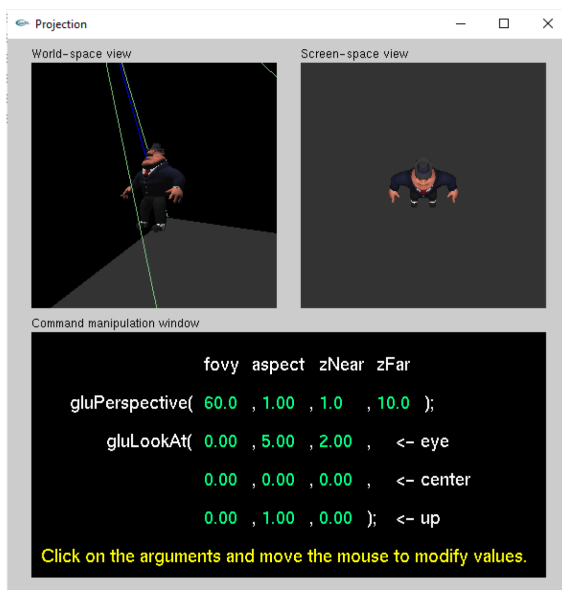

Figure 2. Experiment 1

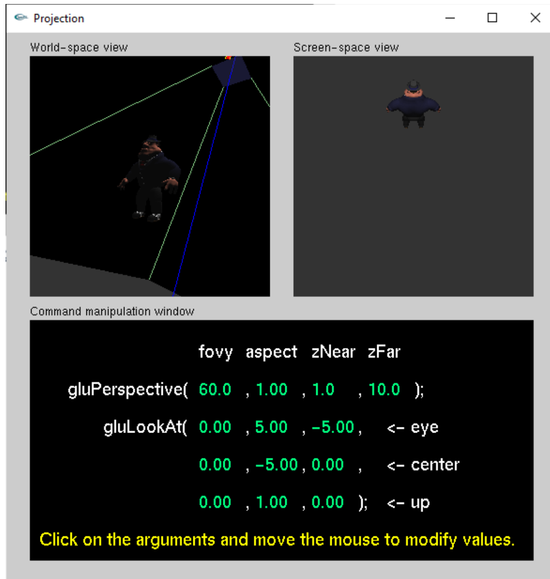

Figure 3. Experiment 2

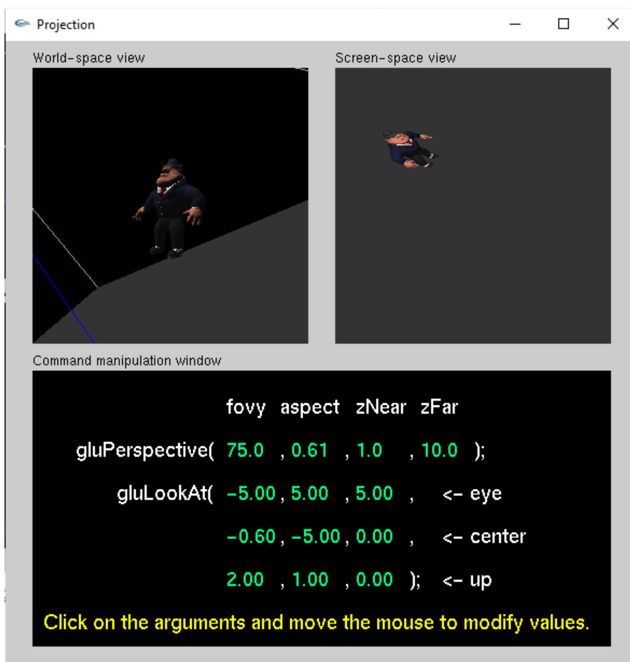

Figure 4. Experiment 3