Comp 575/770 Midterm Answers 6-9

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6.1

1. Translation and Translation? True
2. Translation and Scale? False
3. Translation and Rotation? False
4. Scale and Rotation? False
5. Rotation and Rotation? False

6.2 Write a sequence of 4x4 homogeneous transform matrices to rotate a scene 180 degrees about the axis defined as x = 5 and y = 0. The original question had a typo: 'an axis defined as x = 5.'

1. Translate the space so that the rotation axis becomes the z-axis.

$$\begin{bmatrix} 1 & 0 & 0 & -5 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. Rotate 180 degrees around the z-axis.

$$\begin{bmatrix} \cos(180) & -\sin(180) & 0 & 0 \\ \sin(180) & \cos(180) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3. Translate the space so that the rotation axis is agin defined by x = 5 and y = 0.

$$\begin{bmatrix} 1 & 0 & 0 & 5 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

6.3 What is the conceptual difference between the following homogeneous column vectors:

$$\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 0 \end{bmatrix}$$

When $w = 0$, it is a direction or a point at infinity. The other vector is a position.

7.1 What is the camera matrix for a camera at (x, y, z) with a forward vector (1, 0, 0); up vector (0, 1, 0); and right vector (0, 0, 1). You do not need to calculate the inverse.

$$\begin{bmatrix} 0 & 0 & -1 & x \\ 0 & 1 & 0 & y \\ 1 & 0 & 0 & z \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1}$$

7.2 What is the orthographic projection matrix for a view frustum with the following parameters: top = 10, bottom = 0, right = 20, left = 10, near = -10, far = -90.

$$\begin{bmatrix} \frac{2}{r-l} & 0 & 0 & -\frac{r+l}{r-l} \\ 0 & \frac{2}{t-b} & 0 & -\frac{t+b}{t-b} \\ 0 & 0 & \frac{2}{n-f} & -\frac{n+f}{n-f} \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \frac{2}{10} & 0 & 0 & -3 \\ 0 & \frac{2}{10} & 0 & -1 \\ 0 & 0 & \frac{2}{80} & \frac{100}{80} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

7.3 What would be the value of the points (right, top, near) and (left, bottom, far) after applying only the orthographic projection matrix from the previous question?

$$(right, top, near) \rightarrow (1, 1, 1) \tag{1}$$

$$(left, bottom, far) \rightarrow (-1, -1, -1) \tag{2}$$

8.1 What is an advantage in regards to performance for grids and KD trees (one each)?

1. Grids are fast to construct.

2. KD trees are fast to traverse.

8.2 How do Bounding Volume Hierarchies differ from KD trees in regards to dynamic scenes?
BVHs can be updated for dynamic scenes (where the scene changes at runtime) efficiently.
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1. This is similar to the plane analogy presented in the slides in class.

$$\begin{bmatrix} x_A - x_D & x_B - x_D & x_C - x_D \\ y_A - y_D & y_B - y_D & y_C - y_D \\ z_A - z_D & z_B - z_D & z_C - z_D \end{bmatrix} \begin{bmatrix} \lambda_A \\ \lambda_B \\ \lambda_C \end{bmatrix} = (\vec{P} - \vec{D}) \tag{3}$$

$$\begin{bmatrix} \lambda_A \\ \lambda_B \\ \lambda_C \end{bmatrix} = \begin{bmatrix} x_A - x_D & x_B - x_D & x_C - x_D \\ y_A - y_D & y_B - y_D & y_C - y_D \\ z_A - z_D & z_B - z_D & z_C - z_D \end{bmatrix}^{-1} (\vec{P} - \vec{D}) \tag{4}$$