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HW 1 Due Date: July 14, 2023

1) Identify three major differences between Apple Vision Pro and Meta Quest 3. You can search product specifications online. While they may be many differences, think about what key differences between the two products could be.

<u>Answer:</u>
The key differences between Apple Vision Pro and Meta Quest 3 are:

1. Controller:
The key difference between the Apple Vision Pro and the Meta Quest Pro is the method of interaction in the VR or AR environment. While the Apple Vision Pro allows control through eye, hand, and voice input, the Meta Quest Pro utilizes ergonomic controllers for interaction when immersed in the virtual or augmented reality experience.

2. Display:
The Apple Vision Pro features two micro OLED displays that allow others to see your eyes when you're using augmented reality. However, when you switch to virtual reality, your eyes are not visible from the outside. In contrast, the Meta Quest 3 has an LCD screen but doesn't have a glass front like the Apple Vision Pro. So others cannot see the user's eyes.

3. Battery:
One significant design contrast is that the Meta Quest 3 has an internal battery integrated into the headset, while the Apple Vision Pro includes an external corded battery that can be easily stored in your pocket.

2) What primitives do we use to represent virtual models? What primitive is commonly used and why?

<u>Answer:</u>
- To store the geometrical model in a computer, we need a finite method to describe them and for this we use primitives.
- Points, lines, Quads, 3D objects like sphere, cube, cylinder, triangles are used to represent virtual models.

- Geometric models are represented in terms of primitives, the simplest and common form is a 3D triangle. Triangles are heavily used, e.g., for ease of manipulation on GPUs.

3) Canonical view transform uses Tst with the following formula:
Describe what role the values on the first row-first column and third row-fourth column play in the chain of transformations?

Answer:
The first row-first column value (2/(r-l)) denotes scaling the x-dimension of the frustum and making the dimension of the cube as 2. It determines the horizontal scaling factor applied to the scene during the transformation. The variables 'r' and 'l' represent the right and left coordinates of the frustum, respectively.

The third row-fourth column(-(n+f)/(n-f)) translates the z values so that the eye is at the center of the cube-shaped frustrum. The variables 'n' and 'f' represent the near and far distances of the frustum, respectively.

4) Consider a triangle model in R3 with vertices as (1,3,4), (8,-4,5), and (1,-2,-4). Find the new values of each vertex coordinate, if the triangle is first rotated along x, z, and y axis by 45, 30, and 60 degrees and then shifted along the x, y, and z directions by -1, -3, and 7 values?

5) Consider a point in 3D with values (3,5,7). What would be the coordinate of the point if it is inversely rotated along z axis by 30 degrees? Note that rotation along z axis is referred to as rolling.

Answer:

I solved the question 4 and 5 in handwritten notes below:

4

Step1

R_x (beta)

Angle = 45°

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos 45^\circ & -\sin 45^\circ \\ 0 & \sin 45^\circ & \cos 45^\circ \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.707 & -0.707 \\ 0 & 0.707 & 0.707 \end{bmatrix}$$

Step2

R_z (gamma)

Angle = 30°

$$\begin{bmatrix} \cos 30^\circ & -\sin 30^\circ & 0 \\ \sin 30^\circ & \cos 30^\circ & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0.866 & -0.5 & 0 \\ 0.5 & 0.866 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Step3

R_y (alpha)

Angle = 60°

$$\begin{bmatrix} \cos 60^\circ & 0 & \sin 60^\circ \\ 0 & 1 & 0 \\ -\sin 60^\circ & 0 & \cos 60^\circ \end{bmatrix} \quad \begin{bmatrix} 0.5 & 0 & 0.866 \\ 0 & 1 & 0 \\ -0.866 & 0 & 0.5 \end{bmatrix}$$

Step4: Rotation along x, z and y axis as given in the problem statement

As we are doing from right to left

R(alpha, gamma, beta) = Ry(alpha) · Rz(gamma) · Rx(Beta)

First of all, we do matrix multiplication of Rx and Rz

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.707 & -0.707 \\ 0 & 0.707 & 0.707 \end{bmatrix} \cdot \begin{bmatrix} 0.866 & -0.5 & 0 \\ 0.5 & 0.866 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0.866 & -0.5 & 0 \\ 0.353 & 0.612 & -0.707 \\ 0.353 & 0.612 & 0.707 \end{bmatrix}$$

step5 :

Now, multiplying the above result to R_y (alpha) resulting matrix will be rotation matrix

0.866	-0.5	0	·	0.5	0	0.866
0.353	0.612	-0.707		0	1	0
0.353	0.612	0.707		-0.866	0	0.5

=

0.433	-0.5	0.749
0.788	0.612	-0.048
-0.436.	0.612	0.658

step6 : Now consider 4*4 matrix & apply the above rotation result in the below formula x, y, z translations

Points are -1, -3, 7

$$\left[\begin{array}{ccc|c} & R & & x_t \\ & & & y_t \\ & & & z_t \\ \hline 0 & 0 & 0 & 1 \end{array}\right] \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix}$$

Final result

$$
\begin{bmatrix}
0.433 & -0.5 & 0.749 & -1 \\
0.788 & 0.612 & -0.048 & -3 \\
-0.436 & 0.612 & 0.658 & 7 \\
0 & 0 & 0 & 1
\end{bmatrix}
\cdot
\begin{bmatrix}
1 & 8 & 1 \\
3 & -4 & -2 \\
4 & 5 & -4 \\
1 & 1 & 1
\end{bmatrix}
=
\begin{bmatrix}
0.929 & 8.209 & -2.563 \\
-0.568 & 0.616 & -3.244 \\
11.032 & 4.354 & 2.708 \\
1 & 1 & 1
\end{bmatrix}
$$

(5) Rotation matrix for rotation along the z-axis by 30 degrees is :

R_z(gamma)
Angle = 30°

cos 30°	-sin 30°	0
sin 30°	cos 30°	0
0	0	1

Taking the transpose of this matrix will give us the inverse rotation matrix:

$$= \begin{bmatrix} \cos 30^\circ & \sin 30^\circ & 0 \\ -\sin 30^\circ & \cos 30^\circ & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

=

0.866	0.5	0
-0.5	0.866	0
0	0	1

To calculate the new coordinates of the point

0.866	0.5	0
-0.5	0.866	0
0	0	1

$$\cdot \begin{bmatrix} 3 \\ 5 \\ 7 \end{bmatrix}$$

$$= \begin{bmatrix} 5.098 \\ 2.83 \\ 7 \end{bmatrix}$$

Therefore,

new_x = 5.098

new_y = 2.83

new_z = 7