Question Set 5

CS 420

Chapter 5

1. Given

$$\vec{\mathbf{o}}^t = \vec{\mathbf{w}}^t O$$
$$\vec{\mathbf{e}}^t = \vec{\mathbf{w}}^t E$$

   If $\tilde{p} = \vec{\mathbf{o}}^t \mathbf{c}$

   (a) What are $\tilde{p}$'s world coordinates?

   (b) What are $\tilde{p}$'s eye coordinates?

2. In a right-handed coordinate system, imagine a cube 6 ft. in front of your eyes. $\vec{\mathbf{e}}^t$'s origin is between your eyes, with its x-axis to the right and its y-axis up. $\vec{\mathbf{o}}^t$'s origin is the center of the cube, with its x-axis pointing at $\vec{\mathbf{e}}^t$'s origin and its y-axis to the left.

   (a) For each frame, describe the z-axis.

   (b) The cube is translated 6 units along the x-axis with respect to $\vec{\mathbf{o}}^t$. Describe its new position.

   (c) From its original position, the cube is rotated $\pi/2$ radians (90 degrees) about the y-axis with respect to $\vec{\mathbf{e}}^t$. Describe its new position.

3. Watch the *Respect the Frame* video, available from the course web site on phoenix. What frame is used in Version 1, resulting in incorrect behavior? What frame is used in Version 2, resulting in correct behavior?

4. Show how to apply a transformation M to $\vec{\mathbf{o}}^t$ with respect to $\vec{\mathbf{a}}^t$.

5. Explain how $\vec{\mathbf{a}}^t = \vec{\mathbf{w}}^t (O)_T (E)_R$ gives us an auxiliary basis that has $\vec{\mathbf{o}}^t$'s origin and $\vec{\mathbf{e}}^t$'s orientation. How do we construct $(O)_T$ and $(E)_R$?

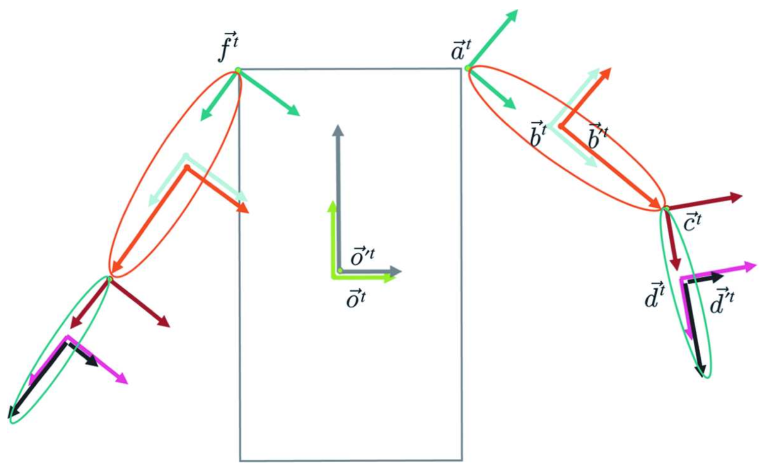
6. Given $\vec{\mathbf{e}}^t = \vec{\mathbf{w}}^t E$ with E such that the eye is located at $[0, 0, 5]$, pointed at $[0, 0, 0]$ (the origin of $\vec{\mathbf{w}}^t$), with an up vector of $[0, 1, 0]$. Let R be a rotation transformation of $\pi/2$ radians (90 degrees) about the y-axis. Let $\vec{\mathbf{a}}^t = \vec{\mathbf{w}}^t A$ where $A = (W)_T (E)_R$. ($W = I$; I is the identity matrix.)

   Describe the effect of performing the updates

   (a) $E \leftarrow ER$ (corresponding to the transformation $\vec{\mathbf{e}}^t = \vec{\mathbf{w}}^t E \Rightarrow \vec{\mathbf{w}}^t ER$)

   (b) $E \leftarrow ARA^{-1}E$ (corresponding to the transformation $\vec{\mathbf{e}}^t = \vec{\mathbf{w}}^t E \Rightarrow \vec{\mathbf{w}}^t ARA^{-1}E$)

7. Consider this robot:



where

(a) $\vec{\mathbf{o}}^t = \vec{\mathbf{w}}^t O$ (torso frame)

(b) $\vec{\mathbf{a}}^t = \vec{\mathbf{o}}^t A$ (right shoulder joint frame)

(c) $\vec{\mathbf{b}}^t = \vec{\mathbf{a}}^t B$ (right upper-arm frame)

(d) $\vec{\mathbf{c}}^t = \vec{\mathbf{a}}^t C$ (right elbow joint frame)

What is the advantage of expressing $\vec{\mathbf{a}}^t$ with respect to $\vec{\mathbf{o}}^t$, rather than respect to $\vec{\mathbf{w}}^t$?