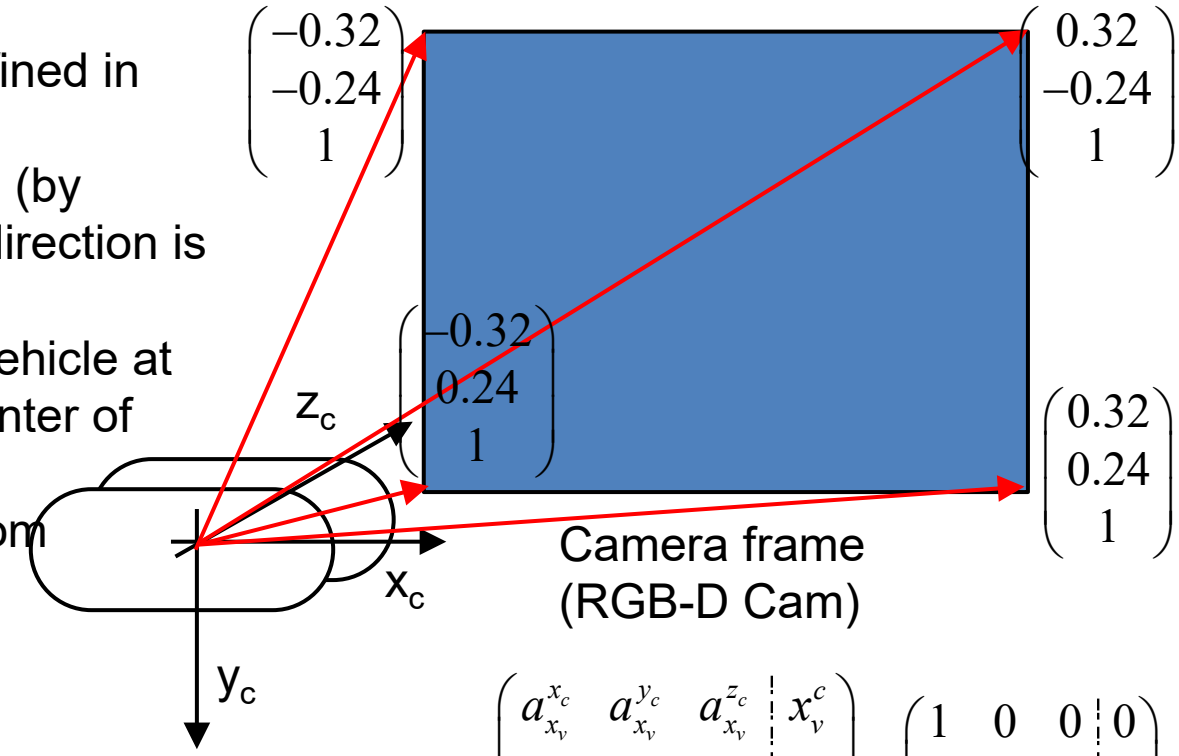
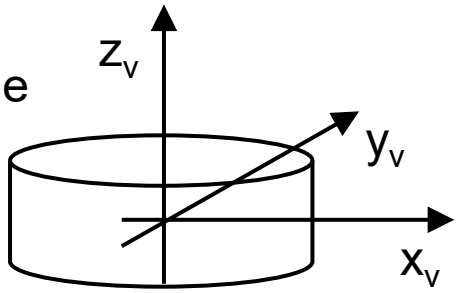
Quiz #2: Frame Transformation in 3D: Frame Conversion from Camera to Vehicle

- Camera has its frame (defined in camera SDK)
- Vehicle has another frame (by convention, e.g., moving direction is x)
- Camera has attached to vehicle at a height of 1.0 m in the center of vehicle
- How do we represent T from camera to vehicle frame

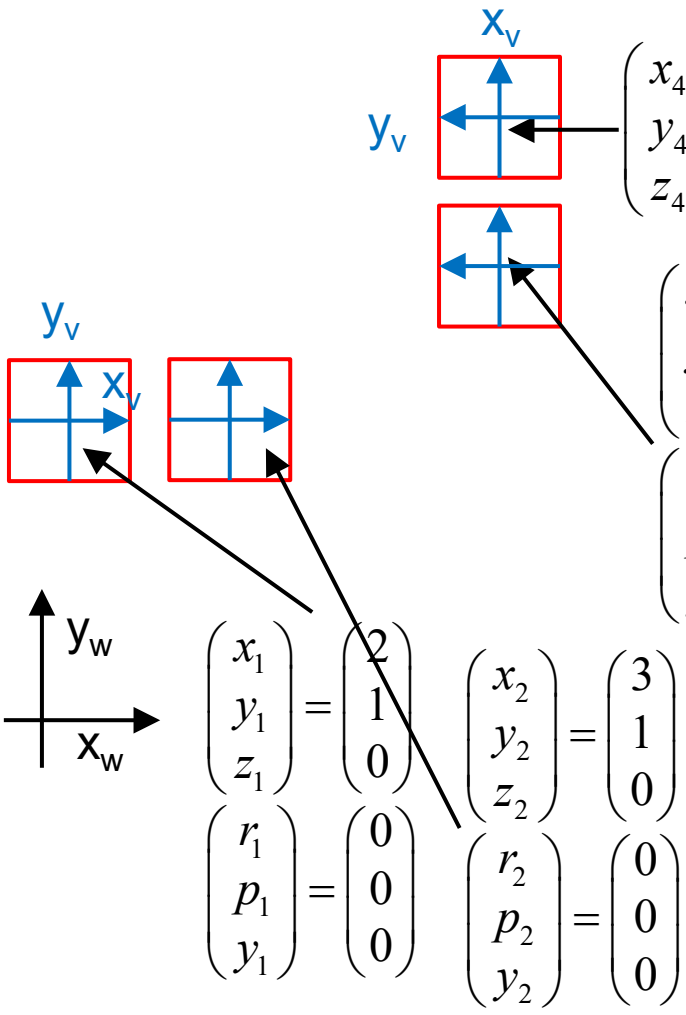


Vehicle frame (Turtlebot)



$$T_v^c = \begin{pmatrix} a_{x_v}^{x_c} & a_{x_v}^{y_c} & a_{x_v}^{z_c} & x_v^c \\ a_{y_v}^{x_c} & a_{y_v}^{y_c} & a_{y_v}^{z_c} & y_c^c \\ a_{z_v}^{x_c} & a_{z_v}^{y_c} & a_{z_v}^{z_c} & z_v^v \\ \hline 0 & 0 & 0 & 1 \end{pmatrix} = \left(\begin{array}{ccc|c} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 \\ \hline 0 & 0 & 0 & 1 \end{array}\right)$$

Quiz #2: Frame Transformation in 3D: Frame Conversion from Vehicle to World



$$\begin{pmatrix} x_4 \\ y_4 \\ z_4 \end{pmatrix} = \begin{pmatrix} 5 \\ 4 \\ 0 \end{pmatrix}, \begin{pmatrix} r_4 \\ p_4 \\ y_4 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \pi/2 \end{pmatrix}$$

$$\begin{pmatrix} x_3 \\ y_3 \\ z_3 \end{pmatrix} = \begin{pmatrix} 5 \\ 3 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} r_3 \\ p_3 \\ y_3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \pi/2 \end{pmatrix}$$

$$\begin{pmatrix} x_1 \\ y_1 \\ z_1 \end{pmatrix} = \begin{pmatrix} 2 \\ 1 \\ 0 \end{pmatrix} \quad \begin{pmatrix} x_2 \\ y_2 \\ z_2 \end{pmatrix} = \begin{pmatrix} 3 \\ 1 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} r_1 \\ p_1 \\ y_1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \quad \begin{pmatrix} r_2 \\ p_2 \\ y_2 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

- Vehicle moves in world frame
- Make a homogeneous transformation matrix from vehicle to world in each vehicle position

$$T_w^{v4} = \left(\begin{array}{ccc|c} a_{x_w}^{x_v} & a_{x_w}^{y_v} & a_{x_w}^{z_v} & x_w^v \\ a_{y_w}^{x_v} & a_{y_w}^{y_c} & a_{y_v}^{z_v} & y_v^w \\ a_{z_w}^{x_v} & a_{z_w}^{y_c} & a_{z_v}^{z_v} & z_v^w \\ \hline 0 & 0 & 0 & 1 \end{array}\right) = \left(\begin{array}{ccc|c} 0 & -1 & 0 & 5 \\ 1 & 0 & 0 & 4 \\ 0 & 0 & 1 & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right)$$

Quiz #2: Frame Transformation in 3D: Problem Setting

Sensor measures the followings at vehicle position 1, 2, 3, 4

$$p^c = \begin{pmatrix} -0.32 \\ -0.24 \\ 1 \end{pmatrix}, \begin{pmatrix} 0.32 \\ -0.24 \\ 1 \end{pmatrix}, \begin{pmatrix} -0.32 \\ 0.24 \\ 1 \end{pmatrix}, \begin{pmatrix} -0.32 \\ 0.24 \\ 1 \end{pmatrix}$$

Make an integrated 3D map in world frame from the measured points at the five vehicle positions: camera frame -> vehicle frame -> world frame

For example,
Measurement at vehicle position 1

$$T_v^c = \left(\begin{array}{ccc|c} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 \\ \hline 0 & 0 & 0 & 1 \end{array}\right) \quad T_w^v == \left(\begin{array}{ccc|c} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right)$$

Measurement at vehicle position 4s

$$T_v^c = \left(\begin{array}{ccc|c} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 \\ \hline 0 & 0 & 0 & 1 \end{array}\right) \quad T_w^v == \left(\begin{array}{ccc|c} 0 & -1 & 0 & 4 \\ 1 & 0 & 0 & 3 \\ 0 & 0 & 1 & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right)$$

Sample Result