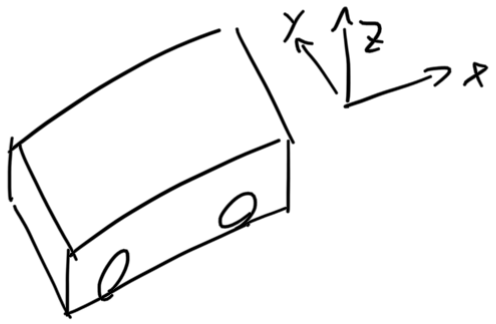
Camera Position : $x = 0.500$, $y = 0.160$, $z = 1.140$

$Z\,Y'\,X''$ | yaw = 90° | pitch = 0° | roll = 100°

Camera properties : $c_x = 636$, $c_y = 548$, $f_x = 241$, $f_y = 238$



camera matrix C :

$$\begin{vmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{vmatrix}$$

$$\begin{vmatrix} 241 & 0 & 636 \\ 0 & 238 & 548 \\ 0 & 0 & 1 \end{vmatrix}$$

object in $(U, V) = (795, 467)$ -> Image coordinates

1. From image coords. to camera coords

$$\begin{vmatrix} sU \\ sV \\ s \end{vmatrix} = C \begin{vmatrix} X_c \\ Y_c \\ Z_c \end{vmatrix} \Rightarrow \begin{vmatrix} X_c \\ Y_c \\ Z_c \end{vmatrix} = C^{-1} \begin{vmatrix} sU \\ sV \\ s \end{vmatrix}$$

homogeneous coordinates

C^{-1}

$$\begin{vmatrix} X_c \\ Y_c \\ Z_c \end{vmatrix} = \begin{vmatrix} \frac{1}{241} & 0 & -\frac{636}{241} \\ 0 & \frac{1}{238} & -\frac{548}{238} \\ 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} s \cdot 795 \\ s \cdot 467 \\ s \end{vmatrix}$$

$$= \begin{vmatrix} \frac{s \cdot 795}{241} - \frac{s \cdot 636}{241} \\ \frac{s \cdot 467}{238} - \frac{s \cdot 548}{238} \\ s \end{vmatrix} = \begin{vmatrix} s & \frac{795 - 636}{241} \\ s & \frac{467 - 548}{238} \\ & s \end{vmatrix}$$

$$\begin{vmatrix} X_c \\ Y_c \\ Z_c \end{vmatrix} = \begin{vmatrix} s \cdot 0.65975 \\ -s \cdot 0.34034 \\ s \end{vmatrix}$$

euclidean norm = 2.7

$\|(X_c, Y_c, Z_c)\| = 2.7$

$$\sqrt{s^2(0.65975)^2 + s^2(0.34034)^2 + s^2} = 2.7$$

$$s\sqrt{(0.65975)^2 + (0.34034)^2 + 1} = 2.7$$

$$s = 2.16788$$

$$\begin{vmatrix} X_c \\ Y_c \\ Z_c \end{vmatrix} = \begin{vmatrix} 1.43026 \\ -0.73782 \\ 2.16788 \end{vmatrix}$$

object in camera coordinates

2. compensate camera rotation

z y' x" are NOT proper euler angles, but Tait-Bryan ones

z y' x" is the usual convention for INTRINSIC rotations with yaw, pitch and roll. Also known as RPY

$R = R_\gamma R_\theta R_\varphi$

↓ yaw ↓ pitch ↓ roll

$\gamma = 90 \quad \theta = 0 \quad \varphi = 100$

→ Be sure about the reference system

Use this

$$\begin{bmatrix} \cos\gamma\cos\theta & \cos\gamma\sin\theta\sin\rho - \sin\gamma\cos\rho & \cos\gamma\sin\theta\cos\rho + \sin\gamma\sin\rho \\ \sin\gamma\cos\theta & \sin\gamma\sin\theta\sin\rho + \cos\gamma\cos\rho & \sin\gamma\sin\theta\cos\rho - \cos\gamma\sin\rho \\ -\sin\theta & \cos\theta\sin\rho & \cos\theta\cos\rho \end{bmatrix}$$

$$\begin{bmatrix} \cos^{0}\gamma\cos^{1}\theta & \cos\gamma\sin^{0}\theta\sin\rho - \sin^{1}\gamma\cos\rho & \cos\gamma\sin^{0}\theta\cos\rho + \sin^{1}\gamma\sin\rho \\ \sin^{1}\gamma\cos^{1}\theta & \sin\gamma\sin^{0}\theta\sin\rho + \cos^{0}\gamma\cos\rho & \sin\gamma\sin^{0}\theta\cos\rho - \cos^{0}\gamma\sin\rho \\ -\sin\theta^{0} & \cos\theta^{1}\sin\rho & \cos\theta^{1}\cos\rho \end{bmatrix}$$

$$\begin{vmatrix} 0 & -\cos\varphi & \sin\varphi \\ 1 & 0 & 0 \\ 0 & \sin\varphi & \cos\varphi \end{vmatrix} = \begin{vmatrix} 0 & 0.17365 & 0.98481 \\ 1 & 0 & 0 \\ 0 & 0.98481 & -0.17365 \end{vmatrix}$$

this matrix maps FROM camera coords TO world coords
apply directly to (X_c, Y_c, Z_c)

$$\begin{vmatrix} X_w \\ Y_w \\ Z_w \end{vmatrix} = \begin{vmatrix} 0 & 0.17365 & 0.98481 \\ 1 & 0 & 0 \\ 0 & 0.98481 & -0.17365 \end{vmatrix} \cdot \begin{vmatrix} 1.43026 \\ -0.73782 \\ 2.16788 \end{vmatrix}$$

$$= \begin{vmatrix} 2.00682 \\ 1.43026 \\ -1.10306 \end{vmatrix}$$

object in shifted world coordinates

3. shift to car reference

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} X_w \\ Y_w \\ Z_w \end{vmatrix} + \begin{vmatrix} 0.5 \\ 0.16 \\ 1.14 \end{vmatrix} = \begin{vmatrix} 2.50682 \\ 1.59026 \\ 0.03694 \end{vmatrix}$$

object in world coordinates

round to 3 places after comma

2.507 1.590 0.037	result	solution from FS QUIZ: 2.507, 1.590, 0.037

solution