Q1.1

From the correspondence relationship. we have

$$x'^T F x = 0$$

$$\Leftrightarrow [0\ \ 0\ \ 1] \begin{bmatrix} | & | & | \\ F_1 & F_2 & F_3 \\ | & | & | \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = 0$$

$$\Leftrightarrow [\, F_{13},\ F_{23},\ F_{33} \,] \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = 0 \Leftrightarrow F_{33} = 0.$$

Q1.2

We have $R = I = \begin{bmatrix} 1 & & \\ & 1 & \\ & & 1 \end{bmatrix}$ and $[t]_\times = \begin{bmatrix} 0 & -t_3 & t_2 \\ t_3 & 0 & -t_1 \\ -t_2 & t_1 & 0 \end{bmatrix}$

So $E = [t]_\times R = \begin{bmatrix} 0 & -t_3 & t_2 \\ t_3 & 0 & -t_1 \\ -t_2 & t_1 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_1 \\ 0 & t_1 & 0 \end{bmatrix}$ $(t_2 = t_3 = 0)$.

So $l_1 = E^T x_2 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & t_1 \\ 0 & -t_1 & 0 \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ t_1 \\ -t_1 y_2 \end{bmatrix}$

$l_2 = E x_1 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_1 \\ 0 & t_1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ -t_1 \\ t_1 y_1 \end{bmatrix}$

both l_1 and l_2 are parallel to the x-axis.

Q1.3

$$p_i = K[R_i | t_i] \cdot \begin{bmatrix} P \\ 1 \end{bmatrix} = K \cdot (R_i P + t_i)$$

$$p_1 = K(R_1 P + t_1) \quad p_2 = K(R_2 P + t_2) \Leftrightarrow P = R_2^{-1}(K^{-1} p_2 - t_2)$$

$$\Rightarrow p_1 = K(R_1 R_2^{-1}(K^{-1} p_2 - t_2) + t_1) = K R_1 R_2^{-1} K^{-1} p_2 - K R_1 R_2^{-1} t_2 + Kt_1$$

$$= R_{rel}\, p_2 + t_{rel}$$

So $\begin{cases} R_{rel} = K R_1 R_2^{-1} K^{-1} \\ t_{rel} = -K R_1 R_2^{-1} t_2 + K t_1 \end{cases}$ $\begin{cases} E = [t_{rel}]_\times R_{rel} \\ F = K^{-T} [t_{rel}]_\times R_{rel} K^{-1} \end{cases}$

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Q 1.4.

Let P and P' be a point and its reflection in real world.
and d and d' be the image of them.

The translation between P and P' is

$$R = I, \quad T = \begin{bmatrix} t_1 \\ t_2 \\ t_3 \end{bmatrix}$$

We have $\begin{cases} d = KP \ ① \text{ and } \lambda d' = KP' \ ② \\ P' = RP + T = P + T \ ③ \end{cases}$

from ① ② ③. We get

$$K^{-1}\lambda d' = K^{-1} d + T$$

$$\Leftrightarrow \lambda d' = d + KT$$

$$\Leftrightarrow \cancel{\lambda [T]_\times d' = [T]_\times d + K}$$

$$\lambda d' [T]_\times = d[T]_\times + KT[T]_\times$$

$$\Leftrightarrow \lambda d' [T]_\times = d[T]_\times$$

$$\Leftrightarrow \lambda d' [T]_\times d'^T = d[T]_\times d'^T \quad ④$$

left side of equition ④ is 0.

So $d[T]_\times d'^T = 0$.

We can view $[T]_\times$ as a fundamental matix F.

$$[T]_\times^T = -[T]_\times.$$

So $F^T = -F$. (skew-symmetric).