1.1

If the image coordinates are normalized, the two corresponding points are $x = [0,0,1]$ and $x' = [0,0,1]$. Because $x'Fx^T = 0$, we can get

$$[0 \quad 0 \quad 1]\begin{bmatrix} F_{11} & F_{12} & F_{13} \\ F_{21} & F_{22} & F_{23} \\ F_{31} & F_{32} & F_{33} \end{bmatrix}\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = [F_{31} \quad F_{32} \quad F_{33}]\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = F_{33} = 0$$

1.2

We can assume the translation matrix is $t = \begin{bmatrix} t_1 \\ t_2 \\ t_3 \end{bmatrix}$

Because $x' = R(x - t)$ and this transformation is only translation parallel to x axis, we can get $R = I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ and $t_3 = t_2 = 0$

And $E = R[t_x] = I * \begin{bmatrix} 0 & -t_3 & t_2 \\ t_3 & 0 & -t_1 \\ -t_2 & t_1 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_1 \\ 0 & t_1 & 0 \end{bmatrix}$

So we can get the epipolar line for C2 is $l_2 = Ex_1 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_1 \\ 0 & t_1 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ -t_1 \\ t_1 y_1 \end{bmatrix}$ and this line is parallel to x-axis and same to the epipolar line l_1

1.3

Use lower-case letters as image points and use upper-case letters as real world points.

We can get

$\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = K[R_1|t_1]\begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = K\left(R_1\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} + t_1\right)$ and $\begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} = K[R_2|t_2]\begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = K\left(R_2\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} + t_2\right)$

and the real world point can be represented as $\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \left(K^{-1}\begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} - t_2\right) * R_2^{-1}$

Then one image point can be represented by $\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = K\left(R_1\left(K^{-1}\begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} - t_2\right) * R_2^{-1} + t_1\right) =$

$KR_1K^{-1}R_2^{-1}\begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} - KR_1R_2^{-1}t_2 + Kt_1$

Finally we can get the result

$$R_{rel} = KR_1K^{-1}R_2^{-1}$$
$$t_{rel} = -KR_1R_2^{-1}t_2 + Kt_1$$
$$E = R_{rel}[t_{relx}]$$
$$F = K^{-T}[t_{relx}]R_{rel}K^{-1}$$

1.4

We can say an arbitrary point A on the object is $A = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$

And the $R = I - 2NN^T = \begin{bmatrix} 1-2x^2 & -2xy & -2xz \\ -2xy & 1-2y^2 & -2yz \\ -2xz & -2yz & 1-2z^2 \end{bmatrix}$

$$t = k\begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

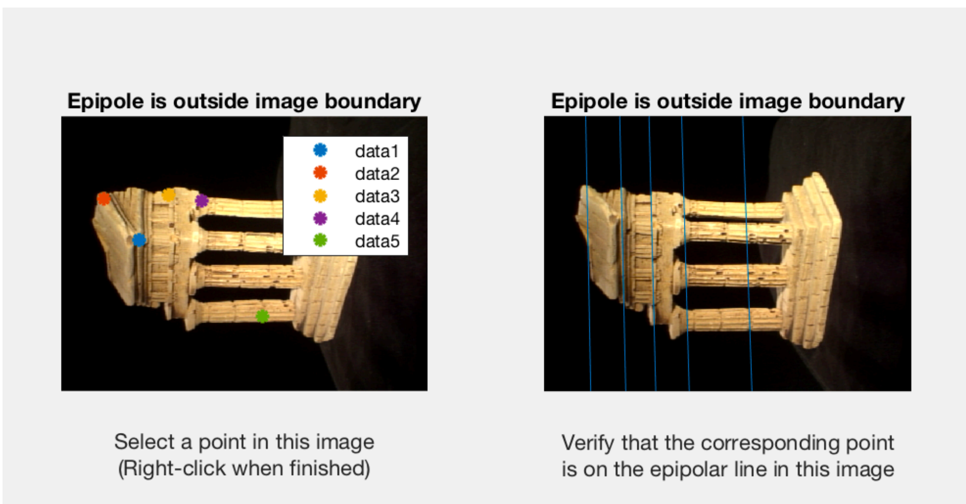
So we can get the $E = [t_x]R = \begin{bmatrix} 0 & -kz & ky \\ kz & 0 & -kx \\ -ky & kx & 0 \end{bmatrix}\begin{bmatrix} 1-2x^2 & -2xy & -2xz \\ -2xy & 1-2y^2 & -2yz \\ -2xz & -2yz & 1-2z^2 \end{bmatrix} =$

$\begin{bmatrix} 0 & -kz & ky \\ kz & 0 & -kx \\ -ky & kx & 0 \end{bmatrix}$

Finally, we can get $F = K^{-T}EK^{-1} = K^{-T}(-E^T)K^{-1} = -(K^{-T}EK^{-1})^T = -F^T$

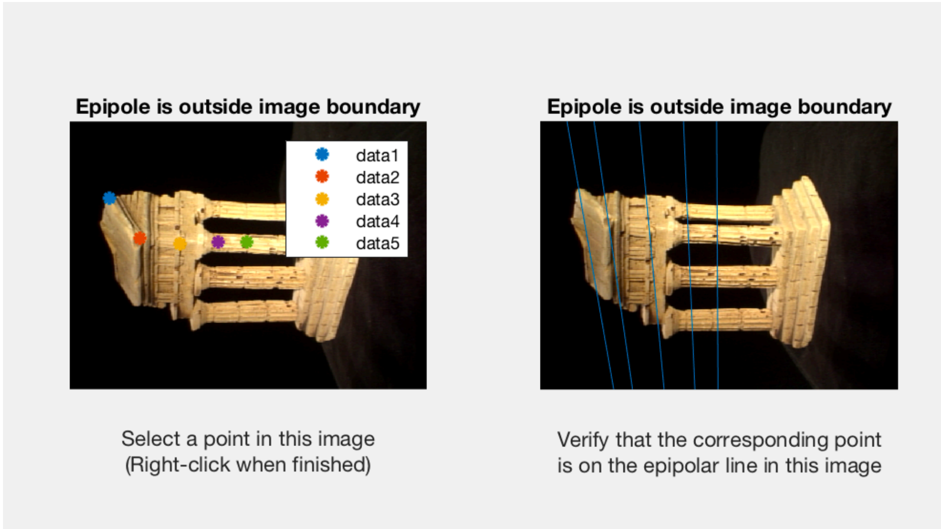
2.1

$F = \begin{bmatrix} -1.310951264370002e-09 & -1.308290656772906e-07 & 0.001124715246002 \\ -5.921318702546828e-08 & 3.564406722080434e-09 & -1.650299588884945e-05 \\ -0.001080133996493 & 3.047751258987522e-05 & -0.004165831804642 \end{bmatrix}$



2.2

$F = \begin{bmatrix} 6.717780008346810e-08 & 1.779027072066887e-06 & -0.002469168327910 \\ -1.510702323985637e-06 & -5.524069882753711e-08 & 5.026249827532084e-04 \\ 0.002367270966298 & -4.890216415683362e-04 & 0.005120920625693 \end{bmatrix}$



3.1

The E I got is

$$\begin{bmatrix} -0.003030416127690 & -0.303520601230333 & 1.660308953073076 \\ -0.137373312525719 & 0.008299260566660 & -0.051154853735289 \\ -1.665063449108456 & -0.012504423130672 & -0.001324288758394 \end{bmatrix}$$

3.2

$$A = \begin{bmatrix} yp_3^T - p_2^T \\ p_1^T - xp_3^T \\ y'p_3'^T - p_2'^T \\ p_1'^T - x'p_3'^T \end{bmatrix}$$

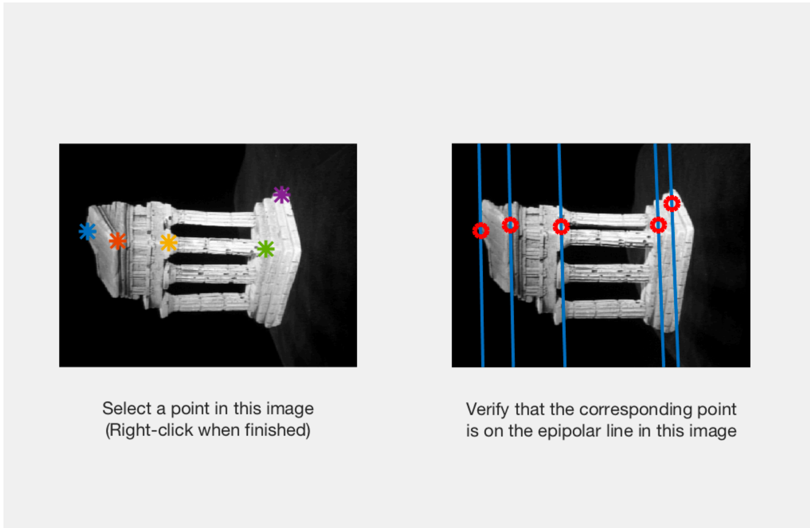
3.3

The sum of squared errors for both projections is 93.1082.

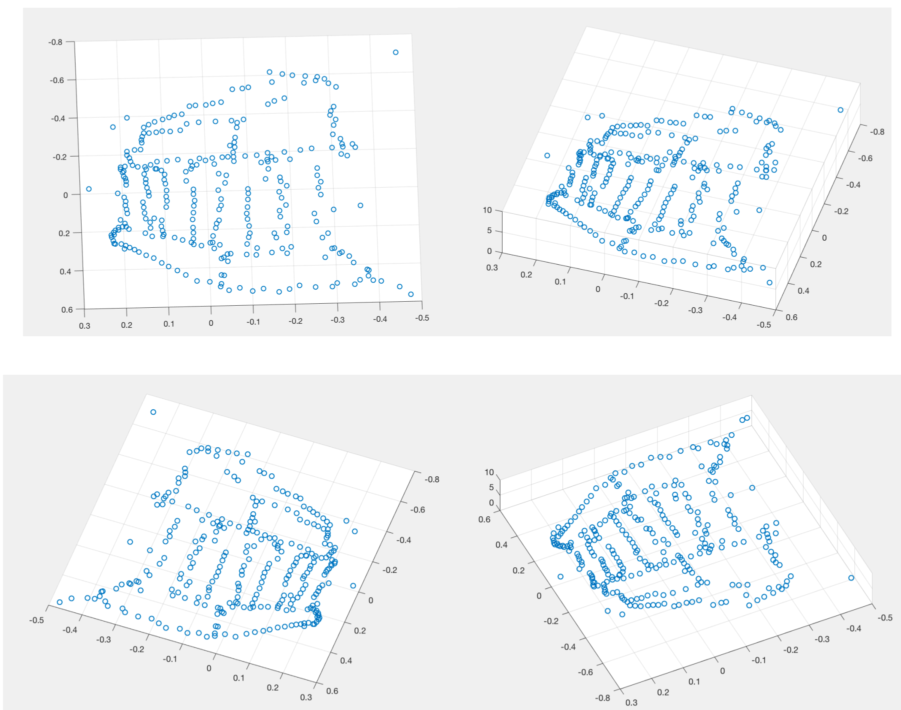
And the C2 I selected is

$$\begin{bmatrix} 1.5196696e+03 & -22.0897060 & 3.051716523018233e+02 & -21.784748553570704 \\ -57.946102 & 1.4080747e+03 & 6.350415319094881e+02 & -1.505518584331076e+03 \\ 0.00125459 & -0.2601003135 & 0.965580785257230 & 0.082559305176506 \end{bmatrix}$$

4.1



4.2



5.1

After I calculate the fundamental matrix F from each possible combination, I use the formula: $x'Fx^T = 0$ to check if a pair of points are inlier.