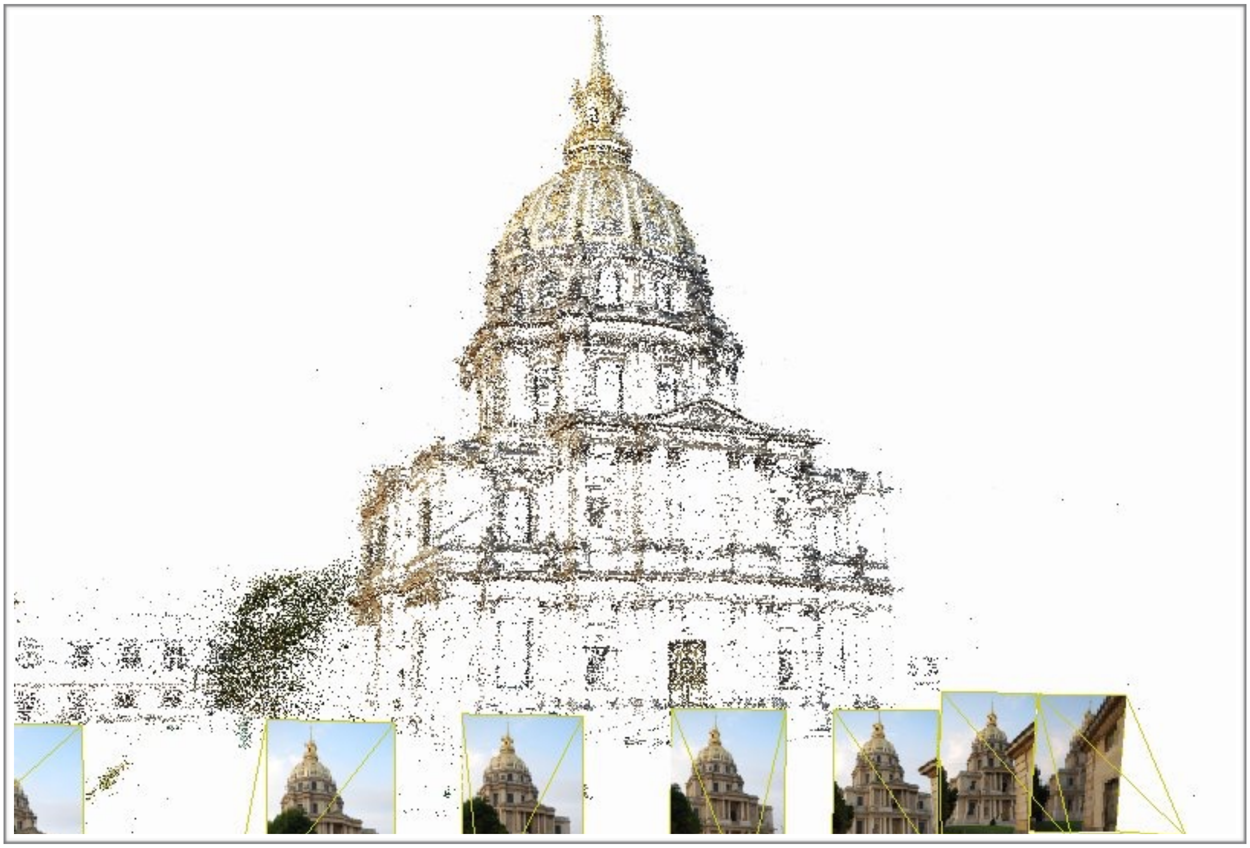
Computer Vision

Stereo Reconstruction



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Homework 4

Q1.1, Q1.2 and Q1.3 REFER HANDWRITTEN SHEETS ATTACHED AT THE END OF THIS REPORT

Q2.1 Code: eightpoint.m

Recovered F is given to be

F =

$$\begin{matrix} 0.0000 & -0.0000 & 0.0031 \\ -0.0000 & -0.0000 & 0.0000 \\ -0.0030 & 0.0000 & -0.0121 \end{matrix}$$

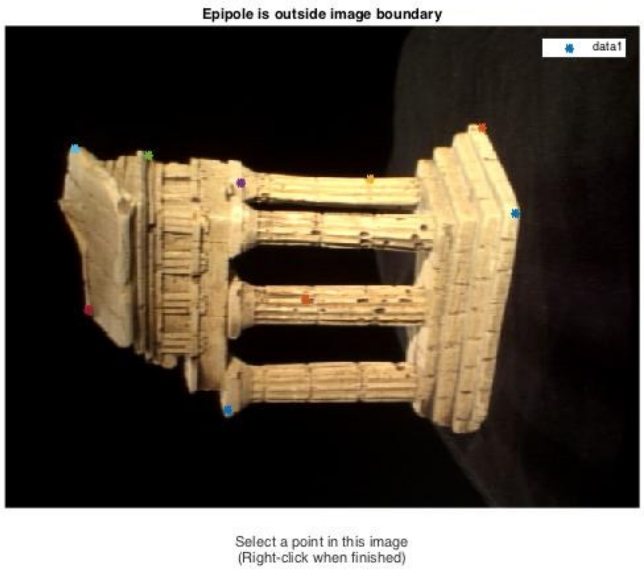
Q 2.2 CODE: sevenpoint.m

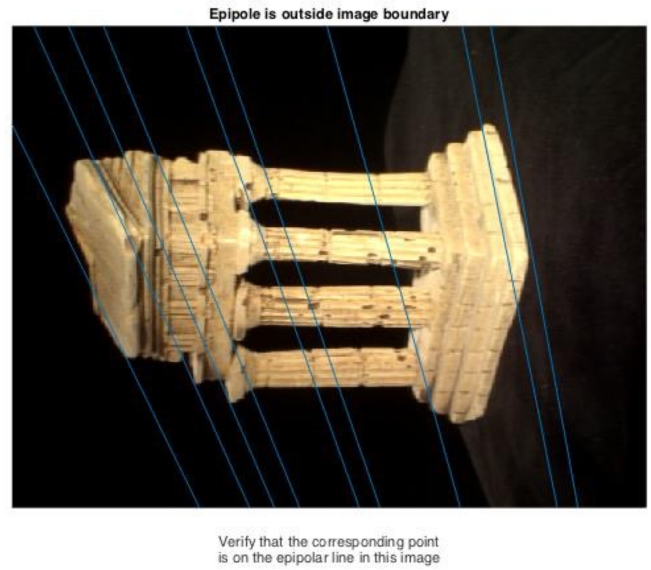
Recovered F is named Fcorrect in the variable name

Fcorrect =

$$\begin{matrix} -0.0000 & 0.0000 & 0.0088 \\ 0.0000 & -0.0000 & -0.0041 \\ -0.0076 & 0.0038 & -0.1080 \end{matrix}$$

Shown below are the point correspondences after choosing only 7 random points using cpselect.

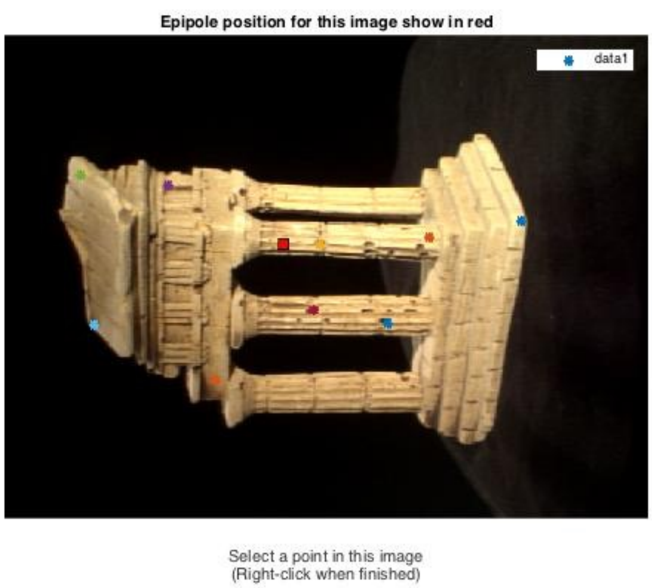


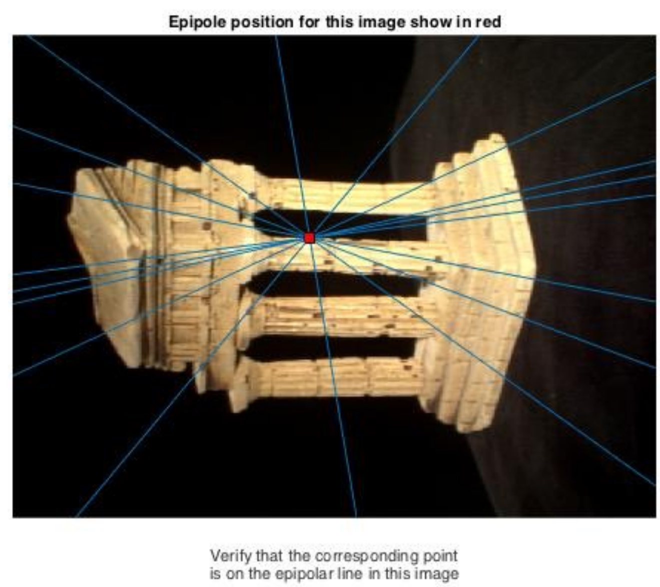


Q2X. CODE: ransacF.m

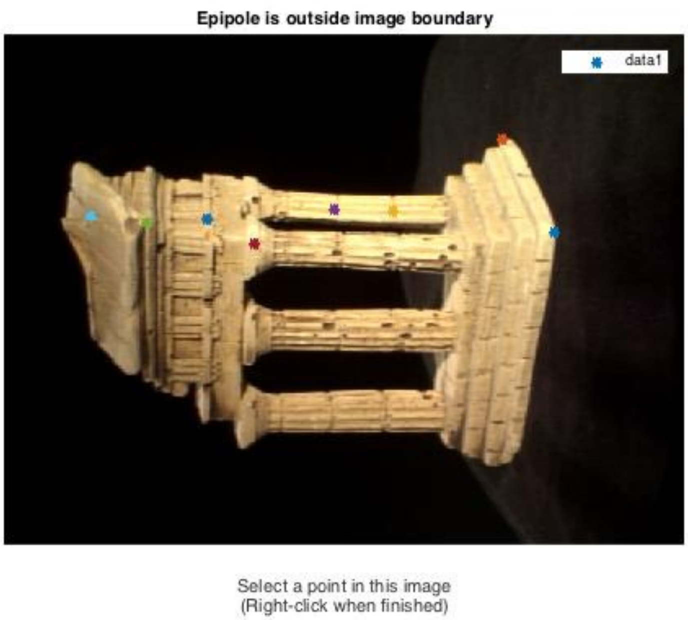
Shown below is a comparison of the RANSAC implemented noisy correspondences and without RANSAC.

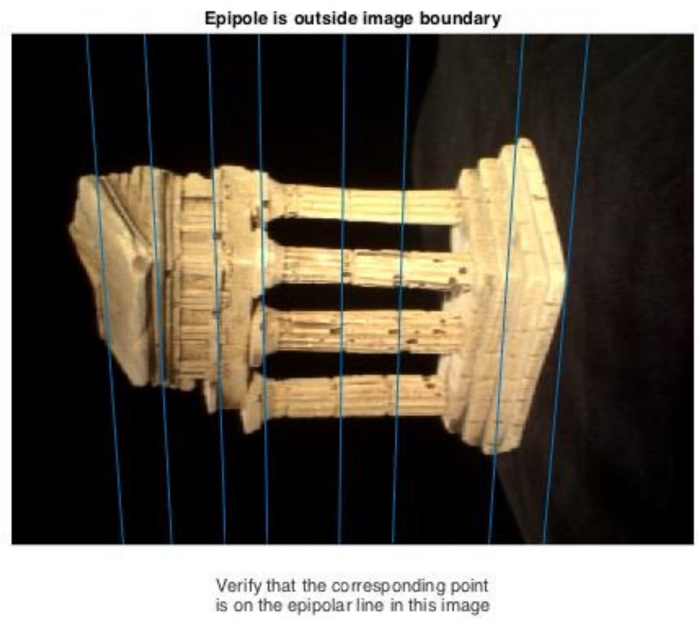
WITHOUT RANSAC:





WITH RANSAC:





Idea behind RANSAC: First the Fundamental Matrix was calculated using an 8 point algorithm. Next we calculated the epipolar line in image 2 and defined the distance metric of the corresponding point in image 2 from the epipolar line to lie within a certain range to be an inlier. At the same time, another distance metric was defined such that the distance of the point in image 1 should lie within a certain range of the left epipolar line. Then it was repeated over several iterations.

Q2.3 CODE: essentialMatrix.m

Estimated value of E comes out to be:

E =

0.0568	-1.1031	4.5982
-0.1539	-0.0020	-0.0121
-4.6073	-0.1472	-0.0014

F =

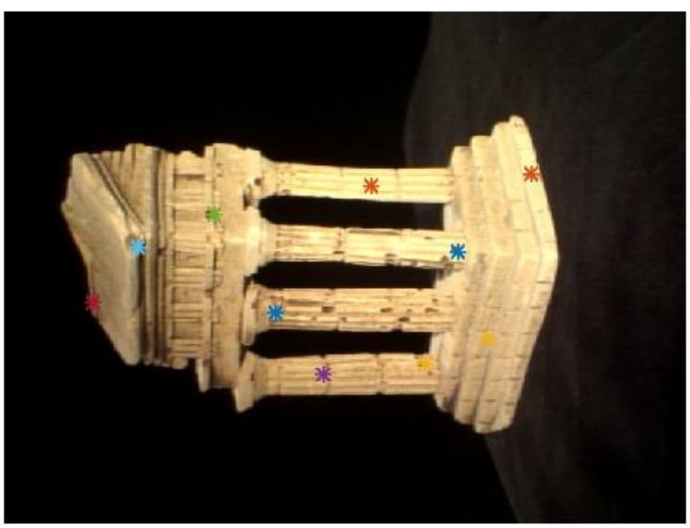
0.0000	-0.0000	0.0031
-0.0000	-0.0000	0.0000
-0.0030	0.0000	-0.0121

Q2.4 CODE: triangulate.m

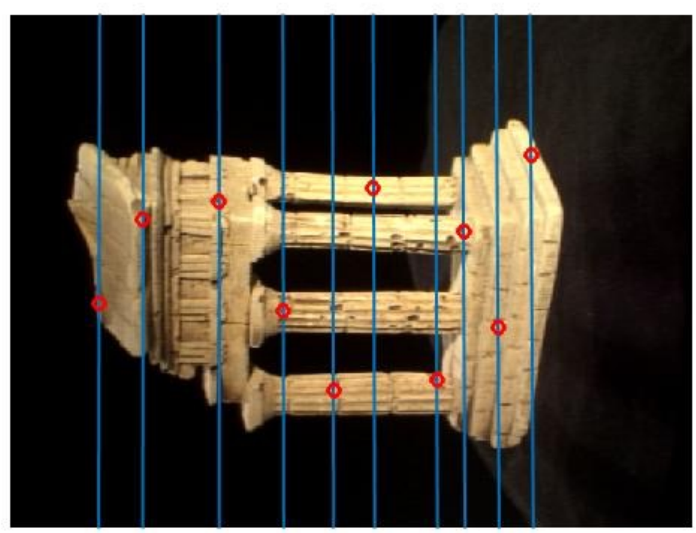
Q2.5 CODE: findM2.m

Q2.6 epipolarCorrespondence.m

Shown below are some of the detected correspondences:



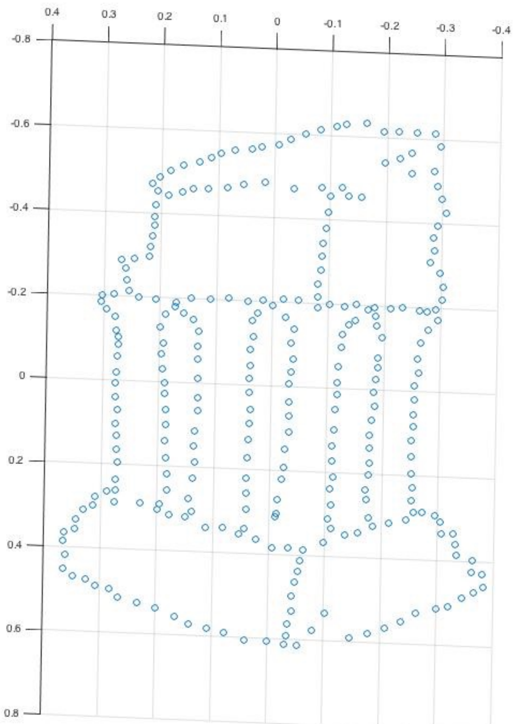
Select a point in this image
(Right-click when finished)

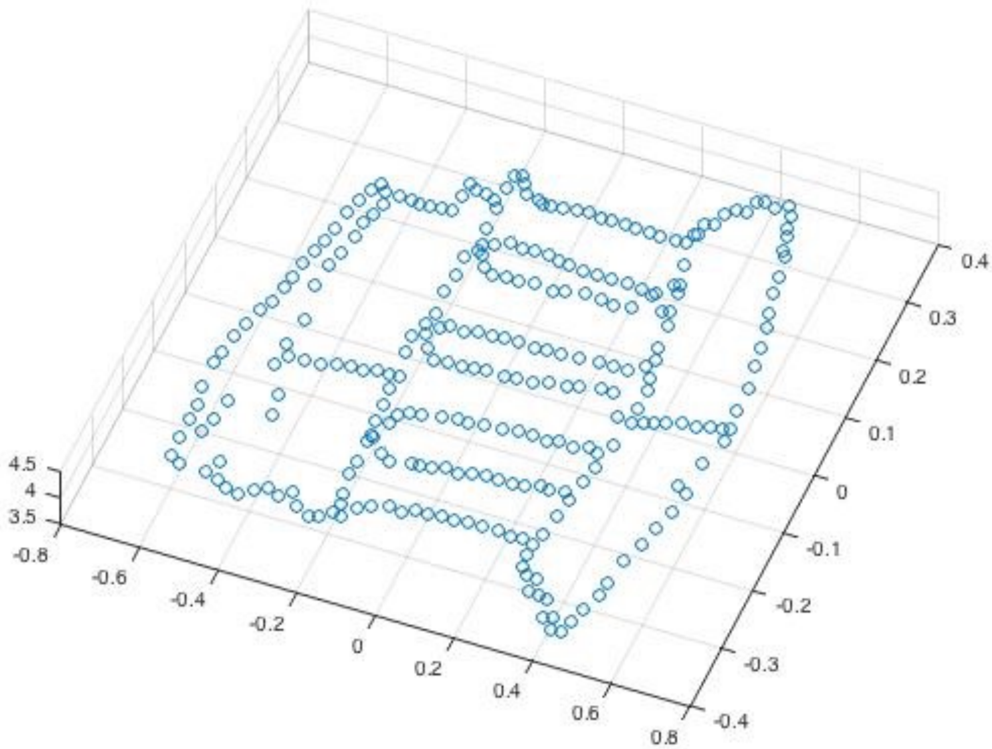


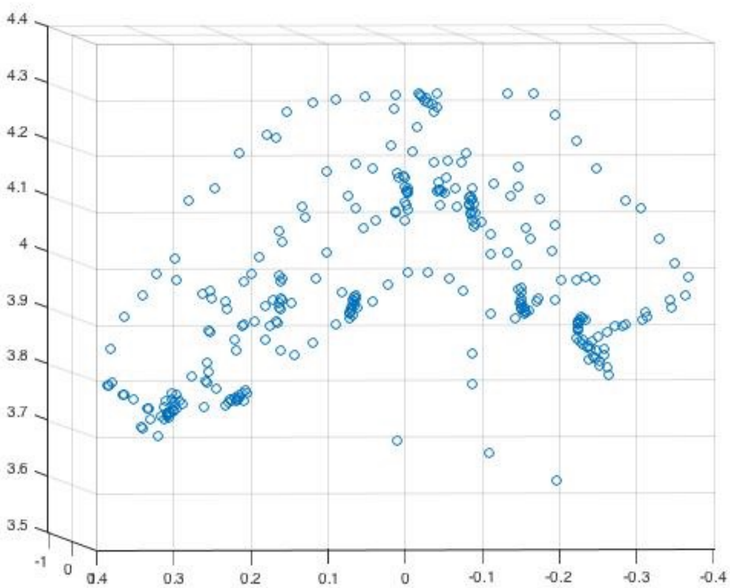
Verify that the corresponding point
is on the epipolar line in this image

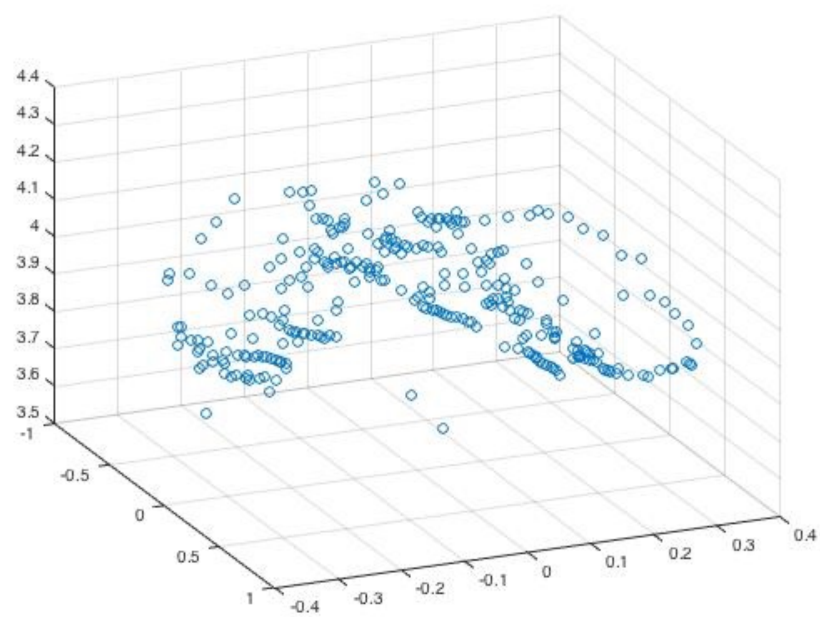
Q2.6 First the using all the above constructed functions, the epipolar line in the second image was determined. Knowing that in the following images the corresponding point lies in a region fairly close to the corresponding point in image 1, I implemented a search space on the epipolar line that was plus or minus 50 pixels within the range of the original point on the epipolar line. This sped up the process fairly well. Also, a 9 window limit was chosen for the descriptors which were then matched with the corresponding descriptor of the point in the left image. A 9 window seemed to do fairly well as compared to a case of 3 or 5 window range. Also, further increasing the size of descriptor would not show marginal improvement as it did to slow down the implementation. Therefore, a 9x9 window range was chosen. A search along the required range was carried out and the euclidean distance metric was chosen to be the similarity metric between the descriptors.

Q2.7. Shown below are some of the angles of the 3D reconstruction



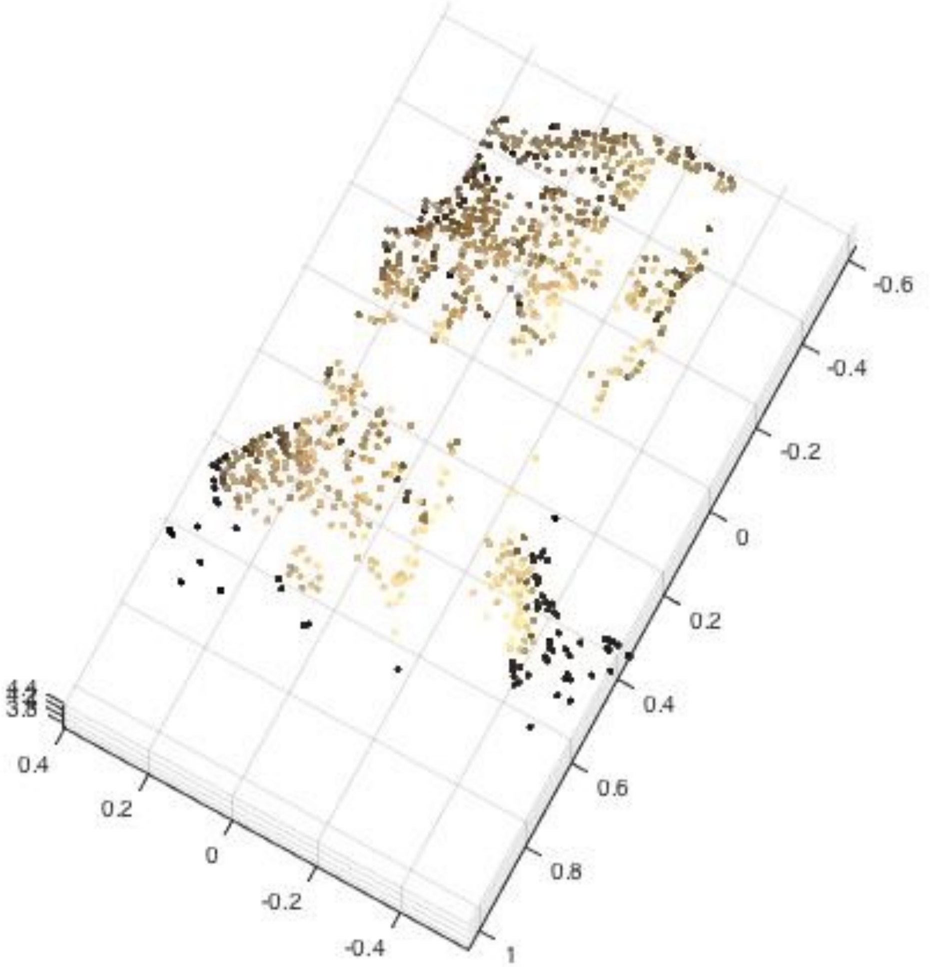


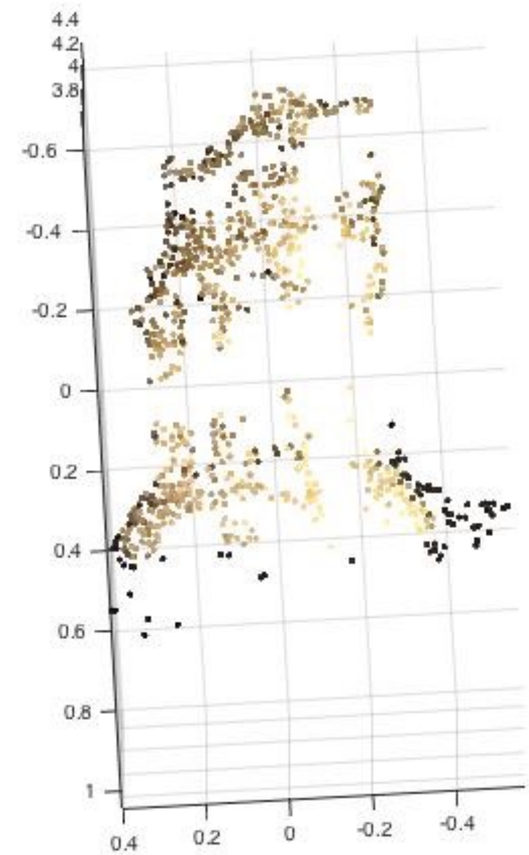


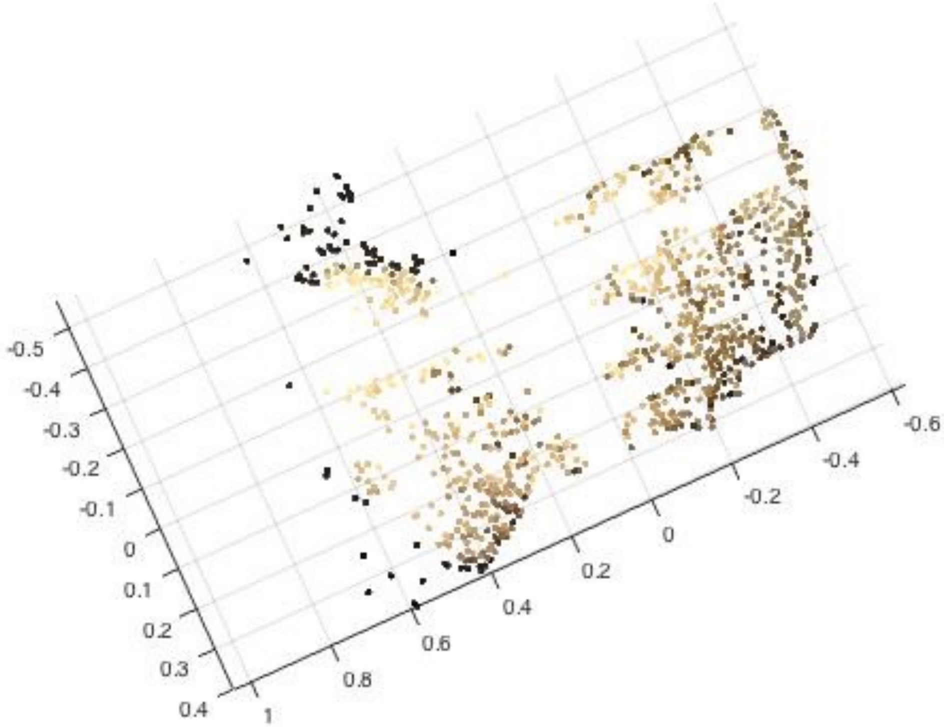


QX. VISUALIZATION OF POINT CLOUD

Shown below are some of the images taken obtained using the dense sampling using MATLAB Vision toolbox. The point cloud for the temple dataset using 2 images are shown.






-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6

Q1.1 We translate each image coordinate system so that origins coincide with the principal point by translations, $\tilde{u} \simeq S^{-1}u$ $\tilde{u}' = S^{-1}u'$

Let the principal point be (u_0, v_0)

The new fundamental matrix is

$$\tilde{F} = S^{T} F S = \begin{bmatrix} F_{2\times2} & F_{2\times3}\, u_0 \\ u_0^T F_{3\times2} & \boxed{u_0^T F u_0} \end{bmatrix}$$

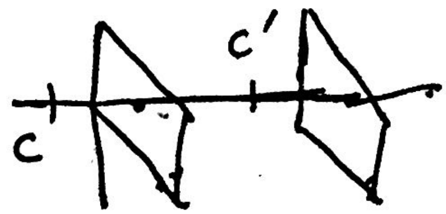
Since there is a case of fixation of cameras therefore u_0 in the left & right images satisfy epipolar constraint $\Rightarrow$ $u_0^T \underline{F u_0} = 0$

Thus new $\tilde{F}$ can be expressed as

$$\tilde{F} = \begin{bmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & 0 \end{bmatrix}$$

Q1.2. Consider the 2nd camera differing from the first by pure translation.

Thus we have $\underbrace{C = C'}_{\text{translation}}$ & $\underbrace{R = I}_{\text{zero rotation}}$



$$F = [C']^{-T} [T_x] R [C^{-1}]$$

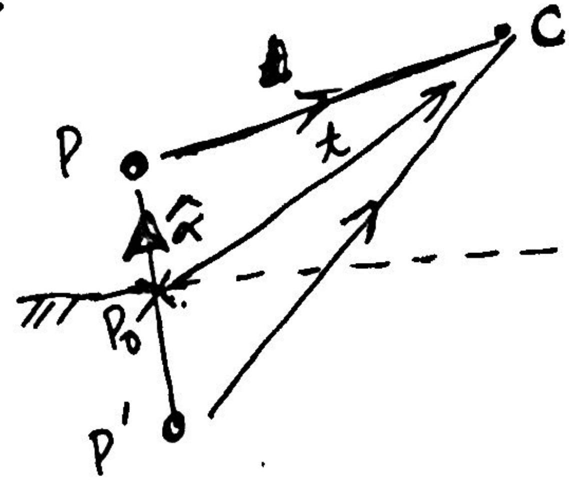
$$= [C^{-T}] [T_x] [C^{-1}]$$

$$= [CT]_x = [e']_x = [e]_x$$

Thus ~~identical~~ equal epipolar lines imply a ~~scaling &~~ parallel nature

Thus epipolar lines of the 2 images are parallel

Q3.



In a global frame,

$$P_0 = \frac{P + P'}{2}$$

$$(2P_0 - P) = P'$$

$$P' = 2P_0 - P$$

Thus we have,
$$\begin{Bmatrix} P' \\ 1 \end{Bmatrix} = \begin{bmatrix} I - 2\hat{\alpha}\alpha' & 0 \\ 0 & 1 \end{bmatrix} \begin{Bmatrix} P \\ 1 \end{Bmatrix}$$

On transforming this system to camera

$$C = [I \mid t] \quad \text{(Pure translation)}$$

Thus
$$p = CP = [I \mid t] \begin{Bmatrix} P \\ 1 \end{Bmatrix}$$
$$p' = CP' = [I \mid t] \begin{Bmatrix} P' \\ 1 \end{Bmatrix}$$
$$= [I \mid t] \begin{Bmatrix} I - 2\hat{\alpha}\alpha' & 0 \\ 0 & 1 \end{Bmatrix} \begin{Bmatrix} P_\infty \\ 1 \end{Bmatrix}$$

$$= [Ex] \begin{Bmatrix} P_\infty \\ 1 \end{Bmatrix}$$

The dual of this problem can be

seen as 2 cameras P & P' observing an object c. But the transformation b/w these cameras is a reflective one.

ie $[2\alpha\alpha^T \; t]$.

We can now note that the essential matrix & $R \to I$

$$E = [T_x] R = \underbrace{[2\alpha\alpha^T t]_\times}_{\text{skew symm}}$$

$$\Rightarrow \boxed{E^T = -E}$$

$$F = K^{-T} E K^{-1}$$

$$F^T = (K^{-T} E K^{-1})^T = K^{-T} E^T K^{-1}$$

$$= -K^{-T} E K^{-1} = -F$$

$$\boxed{F^T = -F}$$

Thus it is a skew symmetric fundamental matrix.