Report: Camera Model

Task 1 & 2

Task 1: Projection Matrix

Projection Matrix M is calculated as p=MX which is in the form of Au=b. A is a 2Nx11 matrix containing homogeneous least squares equation. U is unknown that is 11x1 vector and can be computed by taking pseudo inverse so that $u = (A^T A)^{-1} A^T b$

Reshape the u vector to 3x4 and this in other word is the projection M.

Projection M for the given points is as follows:

```
[[ 0.76785834, -0.49384797, -0.02339781,  0.00674445],
 [-0.0852134 , -0.09146818, -0.90652332, -0.08775678],
 [-0.18265016, -0.29882917,  0.07419242,  1.        ]])
```

As one variable could be 1, so I chose to keep P9 to be 1.

Task 2: Fundamental Matrix

I have computed the fundamental matrix following the normalized 8 point algorithm and then followed the steps described in the YouTube channel UCFCRV lecture 13 by Dr. Mubarak shah. The 2d points are first converted to homogeneous coordinates and then transformation matrices T1 and T2 are constructed for both the images img1 and img2. The transformation factor tx and ty is the centroid of the points where as the scaling factor is 2 pixels which is computed as the mean squared error of the transformed image from it new origin. The formula and the link are as follows:

$$\left(\frac{2N}{\Sigma_{i=1}^{N}||x_i - \bar{x}||^2}\right)^{1/2}$$

https://web.stanford.edu/class/cs231a/course_notes/03-epipolar-geometry.pdf

The value at (2,2) of a normalized fundamental matrix for the required matrices are:

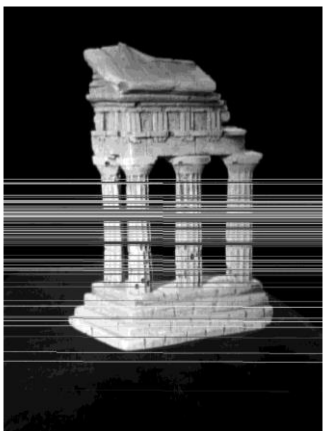
```
Temple: -3.81930862e-03
Ztrans: -1.87972785e-03
Xtrans: -3.07638983e+00
```

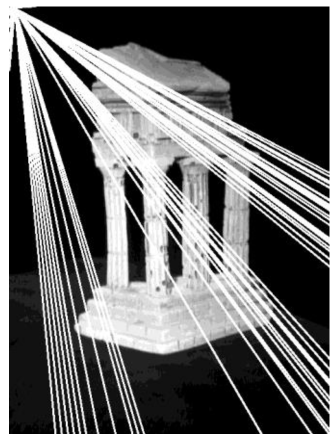
Epipolar lines:

As per the requirement epipolar lines are constructed on 3 set of images. Lines are computed from by l=F*xi. The output is an array containg the values of a,b,c where a,b,c correspond to the equation of line ax+by+c=0. The value of x and y or line coordinates are calculated by once keeping x=0 and then keeping x=len(columns in the image).

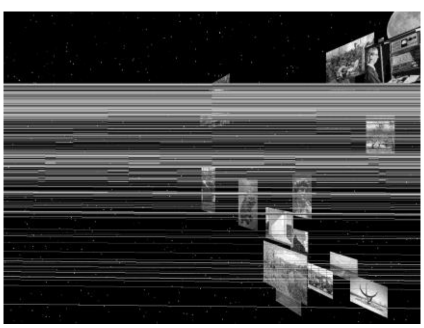
The images with epipolar lines overlaid on the required images are:

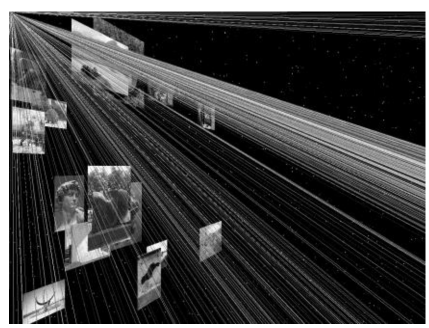
Temple im1 and Temple im2:



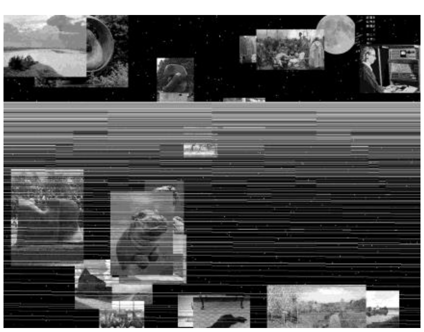


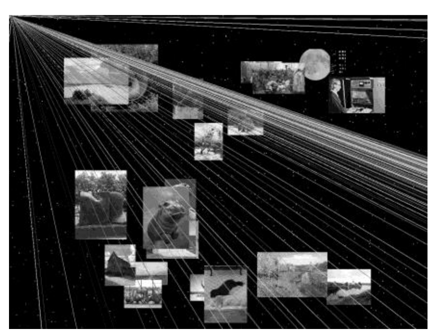
Reallyinwards im1 and im2:





Ztrans im1 and im2:





Epipoles on the required reallyInwards and ztrans of images:

Epipoles are computed from the F matrix, as eF=0 and e'F.T=0. This is solved using the homogeneous least squares equation. Upon solving it manually the equation becomes:

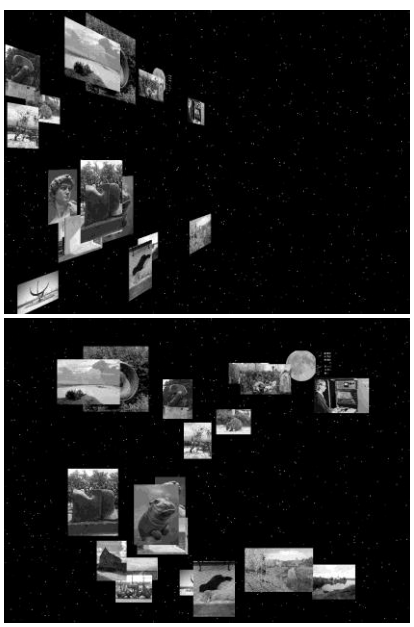
```
#a=[f1 f2]   x=[x]   b=[-f3]
#  [f4 f5]     [y]     [-f6]
#  [f7 f8]             [-f9]
```

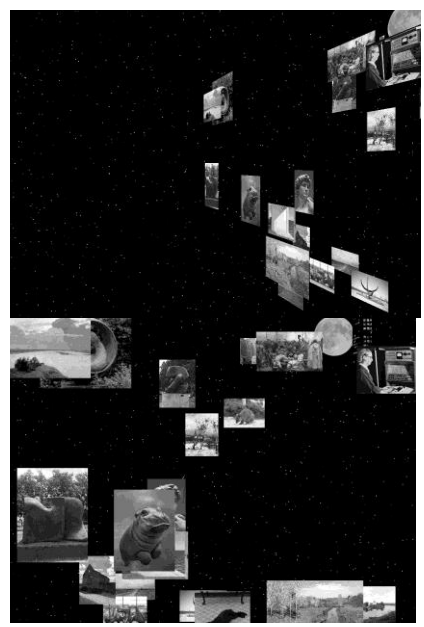
Homogeneous Epipoles for reallyInwards:

```
(array([ 0.00000e+00, -2.62144e+05,  1.00000e+00]),
array([1.00663296e+08, 9.34400000e+04, 1.00000000e+00]))
```

Homogeneous Epipoles for ztrns:

```
(array([9.5744e+04, 7.8976e+04, 1.0000e+00]),
array([4.90355200e+06, 1.15079438e+05, 1.00000000e+00]))
```





Note: Epipoles are not clearly visible that is because of the grey scale color. The values of corresponding epipoles are given for reference.