Computer Vision Lab 3: Epipolar Geometry

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Exercise 1:

In this part, we manually selected 8 corresponding points in two images - stereo1.jpg and stereo2.jpg. These images are shown in figure 1. We used clickPoints function for this. The selected points are represented in figure 2. The resulting points $A1$, $A2$ were then saved in a file points.mat and can be called with command `load points.mat` for later use.

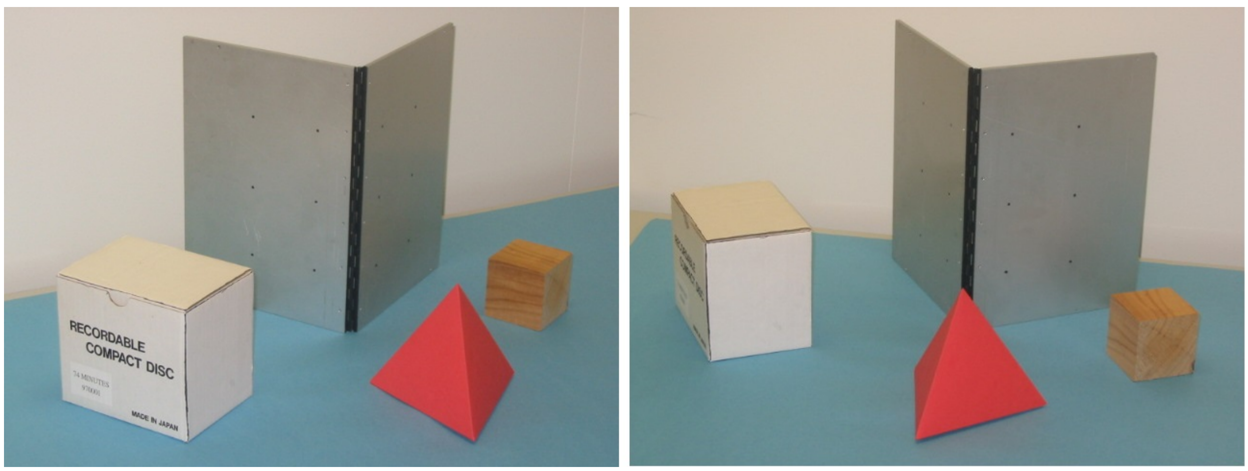

Figure 1: left and right Images

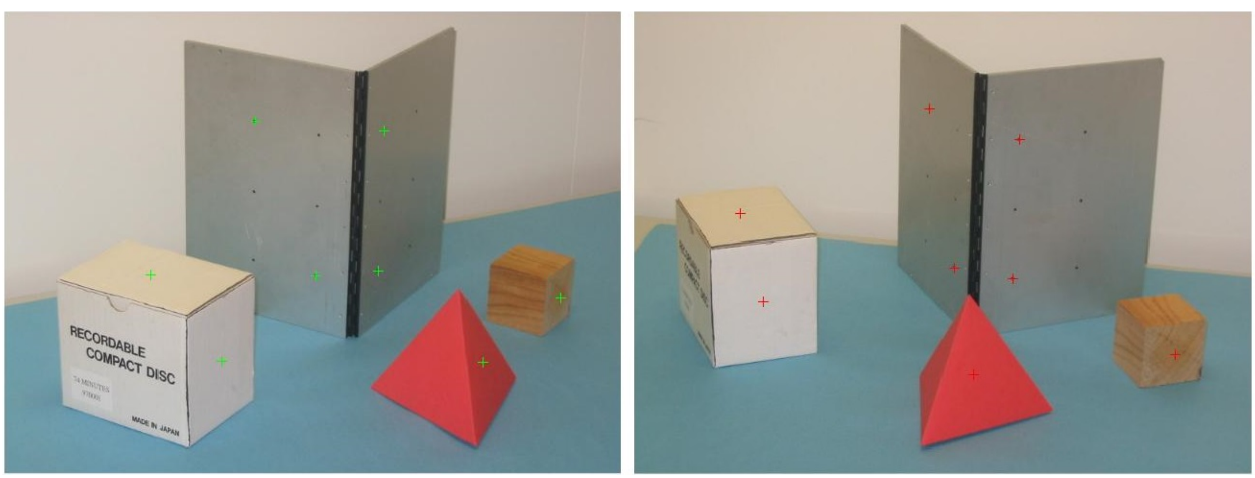

Figure 2: Selected corresponding points (In green (left) and red (right))

Exercise 2: Estimating Fundamental Matrix using 8-point algorithm:

8 point algorithm (Hartley and Zisserman [2003]) is a classic approach to compute fundamental matrix. The code is stored in `MatF.m` and the resulting fundamental matrix is given below:

```
    0.0000    0.0000   -0.0116
   -0.0000    0.0000   -0.0293
    0.0096    0.0097    0.9994
```

The determinant of fundamental matrix was $-7.0038e-24$. F is a singular matrix, so its determinant should be 0.

Exercise 3: Epipoles:

The definitions and concepts of epipoles and epiploar lines has already been provided in the report of previous lab session for Camera Calibration (Stereo system). So here we'll discuss only results. For both camera poses, we estimated epipoles by creating a function `epipoles`. Co-ordinates of these epipoles were:

```
e1 =
    0.7918
   -0.6108
   -0.0016
e2 =
    0.8908
   -0.4543
   -0.0030
```

These epipoles were saved in a file epipoles.mat.

Exercise 4: Epipolar lines:

We implemented a function `click(I1, I2, F)` stored in click.m for finding epipolar lines in the right image corresponding to points in left image. These epipolar lines can be seen in the figure 3.

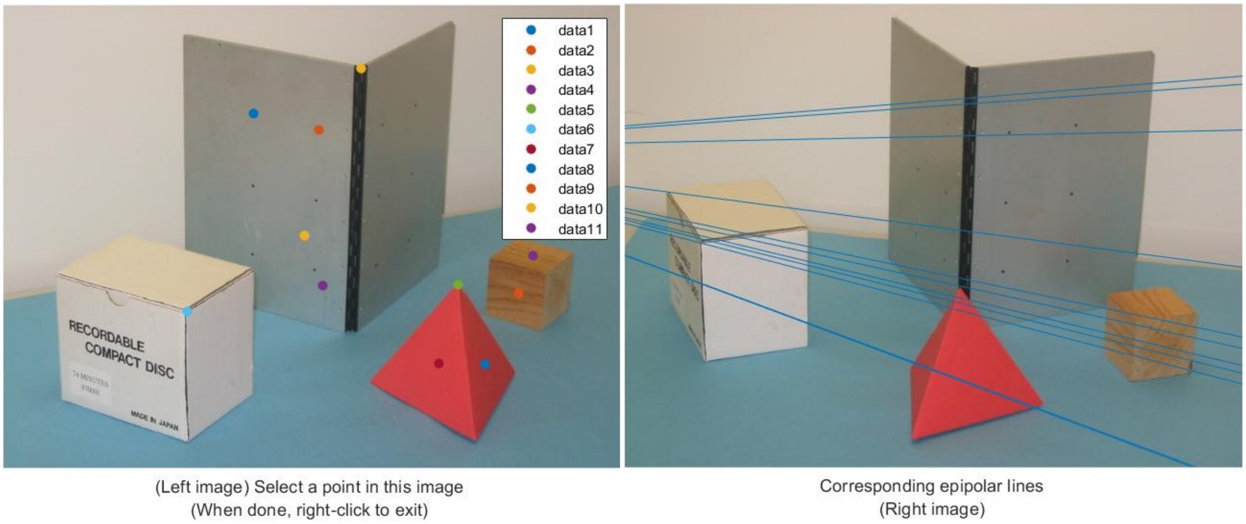

Figure 3: Corresponding Epipolar lines in right image for points in left image

It is clear that the epipolar lines are not entirely accurate. We used the points in `betterPoints.mat` provided in the lab. The new fundamental matrix F and epipoles for points in `betterPoints.mat` were:

```
F =
   -0.0000   -0.0000   -0.0013
   -0.0000   -0.0000    0.0246
   -0.0013   -0.0195    0.9995
```

This is different from the fundamental matrix we calculated through manual selection of points. So our selected points were probably not entirely accurate.

```
e1 =
   -0.9976
    0.0689
   -0.0000
e2 =
   -0.9972
   -0.0745
    0.0005
```

The matlab file `Epipolar_RobinKhatri_betterpoints.m` was used for this computation. This file contains the same process except for the fact that it uses points from `betterPoints.mat`. The results were better and the epipolar lines were almost exact as can be seen in figure 4.

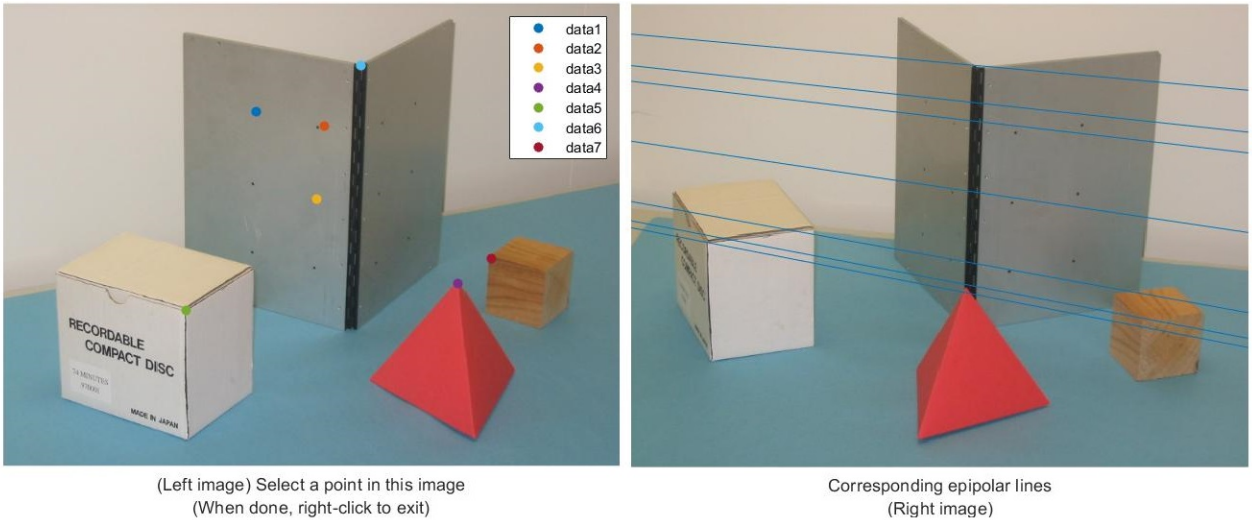

Figure 4: betterPoints.mat: Corresponding Epipolar lines in right image for clicked points in left image

All the functions are stored in the archive file.

Influence of choice of points:

The choice of corresponding points is important as these points are used to build the fundamental matrix which is then used to select corresponding epipolar lines. As seen above the epipolar lines were almost exact after using points from betterPoints.mat, so the points that we selected manually earlier may not have been very accurate.

Another influences of choice of points can come from sparsity of selected points. Recall, for points p_l (left image) and p_r (right image), from epipolar geometry we have,

$$p_r K^{-T}[T_x]RK^{-1}p_l = 0 \tag{1}$$

where $F = K^{-T}[T_x]RK^{-1}$.

And coefficients of matrix F can be calculated from

$$Wf = 0 \tag{2}$$

Where W is a 8×9 matrix we get from 8 corresponding points. Its every row is in form of

$$u_i u_{i'} \ v_i u_{i'} \ u_{i'} \ u_i vi' \ v_i v_{i'} \ v_{i'} \ u_i \ v_i \ i$$

for every point (ui, vi), and f is a 9 dimensional vector containing 9 elements of matrix F

If the image points used to construct matrix W are in a relatively small region of the image, then each vector (Homogeneous co-ordinates) of points in left and right image for p_i and $p_{i'}$ will generally be very similar. Consequently, the constructed W matrix will have one very large singular value, with the rest relatively small (Kenji Hata [2018]). There is obviously still some error but this error can be rectified by using normalized version of 8-point algorithm Hartley [1995]. There can also be algorithmic error during the computation itself as the 8-point algorithm has been prone to such errors as described in described in Jepson [2011].

One other way for introduction of this small error maybe that our fundamental matrix F isn't exactly singular which is a very important property of the fundamental matrix (However our F did have a determinant close to 0).

References

Richard Hartley and Andrew Zisserman. *Multiple view geometry in computer vision*. Cambridge university press, 2003.

Richard I Hartley. In defence of the 8-point algorithm. In *Proceedings of IEEE international conference on computer vision*, pages 1064–1070. IEEE, 1995.

Alan Jepson. Epipolar geometry. `http://www.cs.toronto.edu/~jepson/csc420/`, 2011. [Online; accessed 19-March-2019].

Silvio Savarese Kenji Hata. Cs231a course notes 3: Epipolar geometry. `https://web.stanford.edu/class/cs231a/`, October 2018. [Online; accessed 19-March-2019].