University Jean Monnet

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Computer Vision - Lab 3 Report

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Contents

1 Introduction **2**
1.1 Epipolar Geometry 2

2 Objectives **3**

3 Procedure **3**

4 Conclusion **6**

List of Figures

1 Epipolar Geometry 2
2 8 selected points 3
3 The calculated A and F matrices 4
4 Epipolar lines for points clicked 5
5 Better points and epipolar lines generated with them 5

1 Introduction

In this practical session we take some of the knowledge acquired from camera and stereo calibration tasks in the second practical session and apply it onto the third practical session on Epipolar Geometry.

1.1 Epipolar Geometry

It is the intrinsic projective geometry between two views. It is independent of scene structure, and only depends on the cameras' internal parameters and relative pose. During the course of this lab session light will be shed on the topics of Fundamental matrix, 8 point algorithm, episodes and epipolar lines.

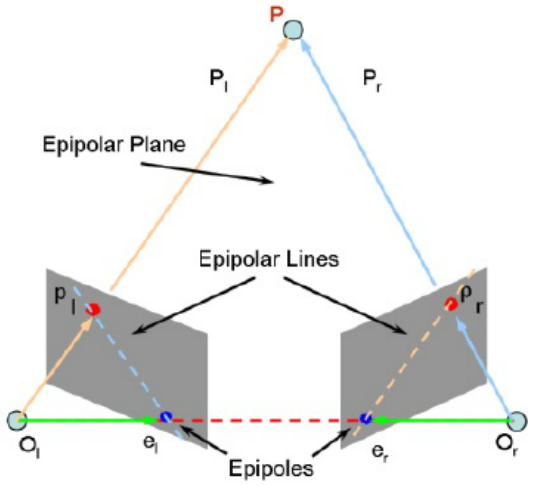


Figure 1: Epipolar Geometry

Figure 1 shows the key elements of the Epipolar geometry.

- Baseline - the line joining the camera centers Ol and Or.
- Epipole - the point of intersection of the line joining the camera centers (the baseline) with the image plane - el and er.
- Epipolar lines - the intersection of an epipolar plane with the image plan - Pl.el and Pr.er.
- Epipolar plane - a plane containing the baseline - P.Ol.Or.

2 Objectives

The lab session had us tasked with three main objectives:

- Task 1: Manually obtain 8 corresponding points from the left and right stereo images.
- Task 2: Calculate the fundamental matrix with 8 point algorithm using SVD.
- Task 3: Calculate the Epipoles of two cameras.
- Task 4 : Implement a function called `click(leftImg,writeImg,F)` which will allow one to see the epipolar line in the right image corresponding to any point clicked in the left image.

3 Procedure

To complete the defined objective, the following steps were taken:

- **Step 1** - The images were read into Matlab along with initializations of N (number of points) and few empty matrices; X1, X2, and F. This was followed by calling the function `clickPoints`, which was used to manually select 8 corresponding points from the left and right stereo images.
  The selected points are shown below in Figure 2

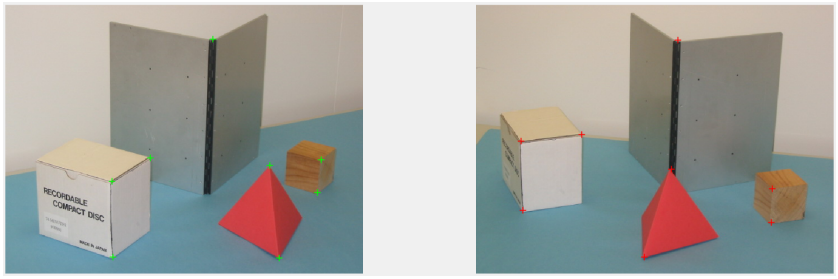


Figure 2: 8 selected points

- **Step 2** - This step entailed the calculation of the fundamental matrix F. The matrix F encapsulates the intrinsic projective geometry between two views. It is a 3×3 matrix of rank 2.
  To do so, we only had to calculate matrix A which was a linear combination of points selected the left and right images.

  The calculated A and F matrices are calculated and displayed in Figure 3

```
A =
   1.0e+05 *
    0.1553    0.2561    0.0008    0.4667    0.7698    0.0024    0.0019    0.0032    0.0000
    0.1631    0.3810    0.0008    0.7096    1.6576    0.0037    0.0019    0.0045    0.0000
    0.4932    0.5197    0.0019    0.6034    0.6359    0.0023    0.0026    0.0027    0.0000
    1.3457    0.2233    0.0036    0.2357    0.0391    0.0006    0.0037    0.0006    0.0000
    1.6591    1.0060    0.0035    1.3929    0.8445    0.0029    0.0047    0.0029    0.0000
    1.4799    1.3659    0.0030    2.2125    2.0420    0.0045    0.0049    0.0045    0.0000
    3.0019    1.4712    0.0053    1.8616    0.9124    0.0033    0.0057    0.0028    0.0000
    2.9571    1.7760    0.0053    2.1759    1.3068    0.0039    0.0056    0.0034    0.0000
```

(a) Matrix A

```
F =
    0.0000   -0.0000   -0.0030
   -0.0000    0.0000    0.0154
   -0.0001   -0.0139    0.9998
```

(b) [Matrix F

Figure 3: The calculated A and F matrices

- **Step 3** - Having calculated F, we next had to calculate the epipoles of the two images. This was done by using the equation `Fe = 0` and `F.Te'`. The resulting epipole vectors were: `e1' = [ 0.9999, 0.0165, 0.0003]` and `e2' = [ -0.9811, -0.1933, 0.0000]`

- **Step 4** - For the final part of the session we had to implement a function `click(leftImg,writeImg,F)` which allowed one to visualize the epipolar lines on the right image for the corresponding points clicked on the left image.
  The lines were constructed using the equations `l' = Fx` and `ax + by + c = 0`. Figure 4 displays the resulting projection when the function is called and the the points are clicked.
  It was observed that for all of the points selected the function was able to deliver accurate corresponding epipolar lines. In order to get precise

results it is imperative to select high contrast points (with respect to the surrounding pixels) during step 1 of the process - as shown in figure 2. If this is not done, one is likely to obtain inaccurate epipolar lines for the selected points.

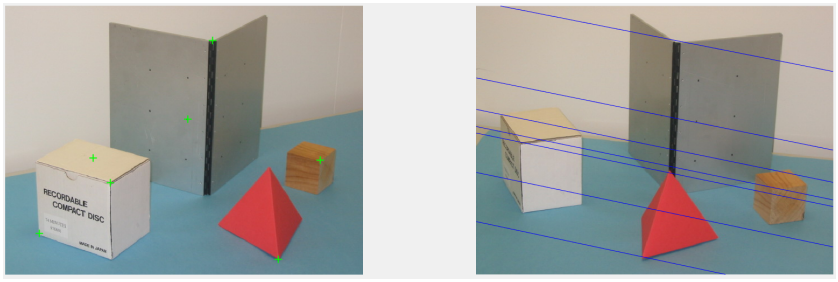
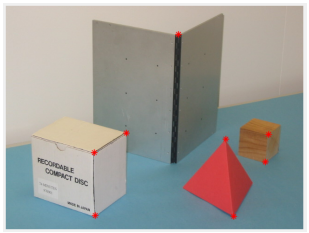
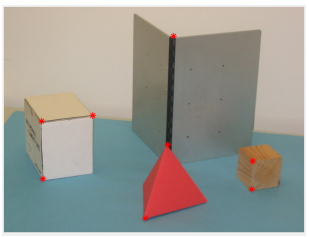


Figure 4: Epipolar lines for points clicked

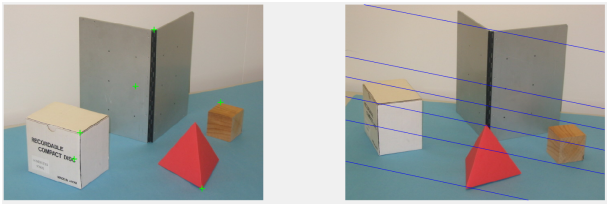
- **Step 5** - The entire process is repeated for another set of points to see if better results were obtained.
  Figure 5 projects the new set of points. It was observed that the selected points were the same as the ones selected by us in step 1, seen in figure 2. Hence the resulting epipolar lines were as accurate as ours.



(a) Better points left



(b) Better points right



(c) Better epipolar lines

Figure 5: Better points and epipolar lines generated with them

4 Conclusion

From the following lab session we were able to gain a broader understanding on epipolar geometry and triangulation based 3D reconstruction. We also understood the importance of selecting high contrast points for the 8 point algorithm to do an efficient job predicting corresponding epipolar lines for selected points. In the next lab session we try and put the knowledge gained form this and the previous lab sessions to realize a 3D reconstruction from a 2D image.