3D CV 3 Exercise

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1 Introduction

This report provides answers to theoretical questions in the second exercise and the result of the developed program.

2 Theory

2.1 A

Given an image point x0 in the first view, how does this constrain the position of the corresponding point x1 in the second image?

Consider an epipolar plane in space not passing through either of the two camera centres. The ray through the first camera centre corresponding to the point x' meets the epipolar plane in a point X. This point X is then projected to a point x in the second image. Since X lies on the ray corresponding to x, the projected point x' must lie on the epipolar line l' corresponding to the image of this ray (figure 1). The points x and x' are both images of the 3D point X lying on a plane. The set of all such points x_i in the first image and the corresponding points x'_i in the second image are projectively equivalent, since they are each projectively equivalent to the planar point set X_i . Thus there is a 2D homography H mapping each x_i to x'_i.

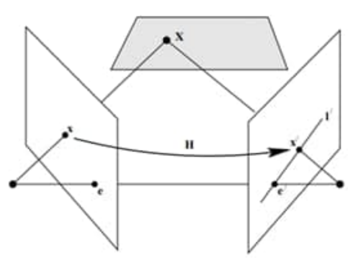

Figure 1: Fundamental matrix

2.2 B

Assume corresponding image points $x_0 \Leftrightarrow x_1$ are given. Describe in words how the 3D world point X can be computed from its projected image points $xi = K_i[R_i|t_i] \cdot (X, 1)^T$ (only the idea, no mathematical derivation).

In order to calculate 3D point, if the corresponding image points $x_0 \Leftrightarrow x_1$ are given, it is necessary to calculate the projection matrix P, which is the dot product of the intrinsic and extrinsic matrices of the camera.

$$P = K \cdot [R|t] \tag{1}$$

$$X = P \cdot x \tag{2}$$

2.3 C

How can the epipoles be computed for the cameras? How are epipolar lines and the epipoles related?

The epipole is the image of the centre of the other camera and according to the task we can compute epipoles as:

$$e = PC' \tag{3}$$

$$e' = P'C, \tag{4}$$

where e and e' - epipoles, P and P' - projection matrix, C and C' - camera centers.

The epipolar lines and the epipoles are related such a way that all epipolar lines intersect at points e and e' in the first and second images, respectively.

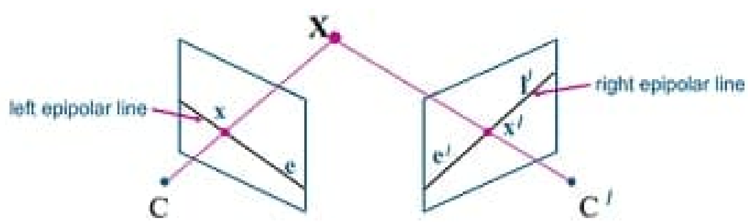

Figure 2: The Epipolar Geometry

2.4 D

How can the fundamental matrix be computed if no calibration is given (only the idea, no mathematical derivation)? If the calibration is not given the fundamental matrix we can use Eq. 5

$$x'^T F x = 0, \tag{5}$$

To calculate F we must know at least 8 corresponding points. Each pair will create a constraint on fundamental matrix.

2.5 E

How can the fundamental matrix be computed if the calibration (intrinsics and pose) is given? (e) If the calibration is given (K, R, t) the fundamental matrix can be computed as in Eq. 5

$$F = K^{-T}[t]_x RK^{-1} \tag{6}$$

where K - intrinsic parameters of the camera, R and t - pose rotation and translation respectively.

2.6 F

Name a fundamental problem of the matching technique used in the pracical part. When does it make sense to match features this way?

The fundamental problem of the matching technique used in the practical part is the correspondence problem to 1D search along an epipolar line. This problem can be reduced by the epipolar constraint. This method can only be used for a small number of points, because a large number of points may cause epipolar lines to overlap or a point may have the same shortest distance from several epipolar lines. In some cases, the different positions of the cameras can affect the result, making the points match ambiguous, because of a huge amount of wrong matches.

3 Practical Part

The code of the developed program is in the "main.py" file.

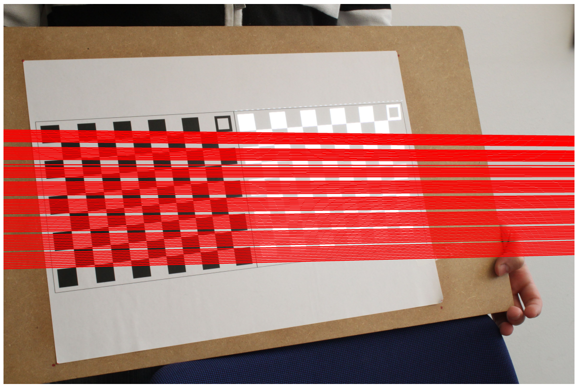

Figure 3: The Epipolar lines

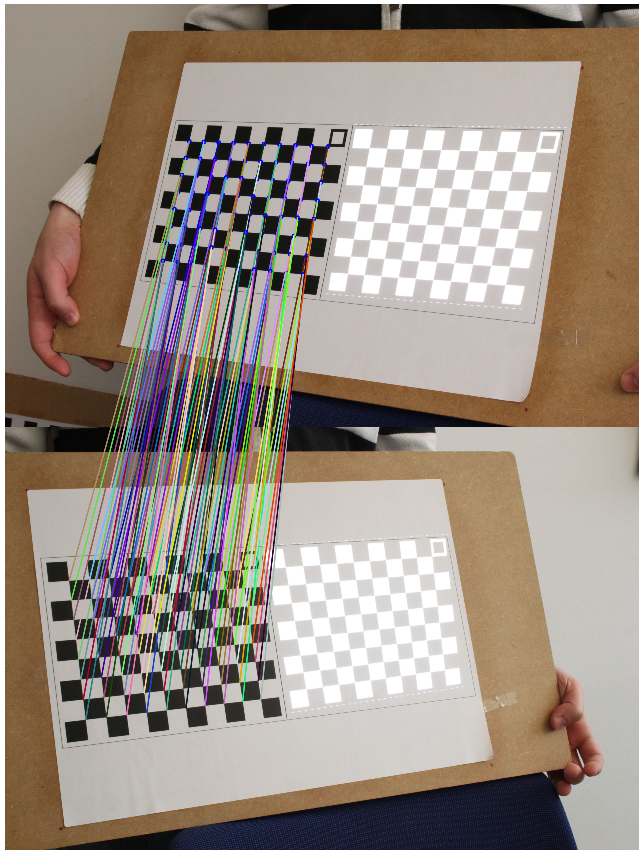

Figure 4: The Matches lines

References

[1] Prof. Didier Stricker, Parameter Estimation, 3D Computer Vision, Kaiserslautern University.

[2] Prof. Didier Stricker, Epipolar Geometry , 3D Computer Vision, Kaiserslautern University.

[3] Prof. Didier Stricker, Structure from Motion , 3D Computer Vision, Kaiserslautern University.

[4] Prof. Didier Stricker, Structure from Motion II , 3D Computer Vision, Kaiserslautern University.