MAEG 5720

Computer Vision in Practice

Assignment 4

Date: 10th, December 2021

Due Date: 18:30pm 20th, December 2021

Submission Guidelines

The folder you hand in must contain the following:

README.txt – contains anything about the assignment that you want to tell the TA, including a brief introduction of the usage of the code.

Code/ - directory containing all your code (**only .m files and image files allowed**) for this assignment, which is expected to have at least one .m file along with one .jpg or .png files.

Report.pdf – **only 1 document** showing the question number, result and comments.

Rename the folder as <your student ID>-Asgn2, and compress it into <your student ID>Asgn2.zip, and upload it to the blackboard system. (For example, 1155123456-Asgn2/ and 1155123456Asgn2.zip, pay attention to the name.)

Please read the guidelines CAREFULLY. If you fail to meet the deadline because of a submission problem on your side, marks will still be deducted.

The late submission policy is as follows:

- 1 day late: -20 marks

- 2 days late: -40 marks

- 3 days late: -100 marks

Pay attention to the format before. **10% deduction for every wrong format** (filename, function name, etc.).

Aim:

The goal of this project is to estimate the epipolar geometry between two related views. The fundamental matrix of two synthetic images will be estimated by implementation of eight-points algorithm. The epipolar lines corresponding to each point will be drawn on the image pairs.

Fundamental Matrix

The fundamental Matrix is given by: $\mathbf{x}_i'^T \mathrm{F} \mathbf{x}_i'' = 0$ where $\mathbf{x}_i'$ and $\mathbf{x}_i''$ are image points on in each image in homogenous coordinates. Those points are constructed in the given file createpts.m by a set of 3D points stored in Point_3D. Two camera matrices M1, M2 are constructed. Your mission is to compose the MATLAB function which takes the two point sets and return the fMatrix which is a 3x3 matrix.

```
function [fMatrix] = FfromEightPnts(xs, xss)
    fMatrix = …;
end
```

For the given set of xs and xss, the fundamental matrix is given by

$$\mathrm{A} = \begin{bmatrix} \mathrm{a}_i^{\mathrm{T}} \\ \vdots \\ \mathrm{a}_n^{\mathrm{T}} \end{bmatrix} \Rightarrow \mathrm{A}\mathbf{f}=0$$

where

$$\mathrm{f} = \mathrm{vecF} = [F_{11}, F_{21}, F_{31}, F_{12}, F_{22}, F_{32}, F_{13}, F_{23}, F_{33}]^T$$

$$\mathrm{a}_i^{\mathrm{T}} = \mathrm{x}_i''^T \otimes \mathrm{x}_i'^T = [x_i'' x_i', x_i'' y_i', x_i'', y_i'' x_i', y_i'' y_i', y_i'', x_i', y_i', 1]$$

The following procedures are required to compute f

1) Normal the points such that their average distance from the centroid is sqrt(2). Please write a MATLAB function in the GetNormMat.m. The function takes the points as input and return the transformation matrix such that $\hat{\mathrm{x}}_i' = T' \mathrm{x}_i'$

2) Each set of correspondence will give you one equation, stack all the equation up to form $\mathbf{Af}$=0. The solution can be found by using singular value decomposition of A=USV'. The solution vector is the last column of V.
3) As Fundamental Matrix is rank 2, a common way to ensure rank(F)=2 is by set S=UDiag(s1, s2, 0) and recalculate the new F=UDiag(s1,s2,0)V'
4) Finally, we have to denormalize the fundamental Matrix i.e. $F = T'^{T} F_q T''$
5) Please be aware MATLAB use another way to represent fundamental matrix. Our calculated Fundamental should be a transpose of MATLAB calculated value. (You may use MATLAB function to verify your calculation)

Question 1 (a) Compute Fundamental Matrix by correspondences (50%)

Question 1 (b) (30%)

A point on one image corresponds to an epipolar line on the other image. The equation for epipolar lines for image one and two are $l' = F\,\mathbf{x}''$ and $\mathbf{l}'' = \mathbf{F}^{T}\mathbf{x}'$ respectively.

Use the fundamental matrix computed. Drawing the epipolar lines on both images. Show the effect of conditioning the fundamental matrix to rank 2 when noise is added to the measurement points.

Question 1 (c) (20%)

The epipoles are the intersection of all epipolar lines. Please show the epipoles equal to the null space of F' and F

Please submit your createpts.m, FromEightPnts.m and GetNormMat.m and a report to discuss how the normalization process can help to improve the of the 8-eight algorithm when noise is added to the 2D points.

Should you have any question, please feel free to contact TA or me by email. Good luck!