UNIVERSITY OF MARYLAND,COLLEGE PARK

PROJECT 4

ENPM 673 PERCEPTION FOR AUTONOMOUS ROBOTS

Kiran Ajith 119112397

April, 2023

Contents

1

1.1 Problem

The aim of the project is to implement the concept of Stereo Vision. Given are 3 different datasets containing two images captured on the same scenario but from different angles. Also given is a *calib.txt* file, which contains the calibration information

1.2 Pipeline

Given below is the pipeline followed for the project.
Each step of the pipeline is given below.

1.2.1 Calibration

First we identify the similarities between each of the two images using a feature extractotr such as SIFT,SURF or SIFT detector. Then we can use a matcher like Bf matcher or FLANN to find the best matches. In this project, we will be using the SIFT to detect and compute key points a to find the best matches.

1.2.1.1 Fundamental Matrix

The fundamental matrix is a 3×3 matrix that is used to relate the corresponding points in two different images taken from different angles. The fundamental matrix can be described as an algebraic representation of epipolar geometry. A homogenoeus linear system can be formed and it can be written as follows:

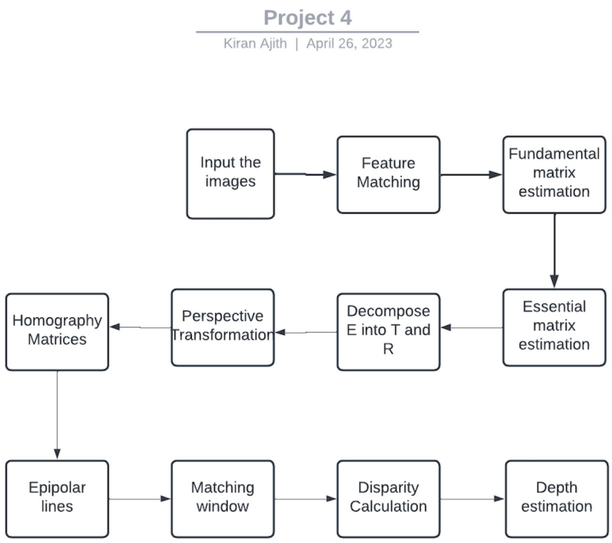


Figure 1.1: Flowchart representing the various processes involved

$$\begin{bmatrix} x_i' & y_i' & 1 \end{bmatrix} \begin{bmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & f_{33} \end{bmatrix} \begin{bmatrix} x_i \\ y_i \\ 1 \end{bmatrix} = 0$$

where the 3×3 matrix f_i is the fundamental matrix

$$\begin{bmatrix} x_1x_1' & x_1y_1' & x_1 & y_1x_1' & y_1y_1' & y_1 & x_1' & y_1' & 1 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_mx_m' & x_my_m' & x_m & y_mx_m' & y_my_m' & y_m & x_m' & y_m' & 1 \end{bmatrix} \begin{bmatrix} f_{11} \\ f_{21} \\ f_{31} \\ f_{12} \\ f_{22} \\ f_{32} \\ f_{13} \\ f_{23} \\ f_{33} \end{bmatrix} = 0$$

If the correspondence between the images is greater than 8, then the fundamental matrix can be obtained by formulating the above equation as $AX = 0$ and can be solved by linear least squared using SVD.

1.2.2 Rectification

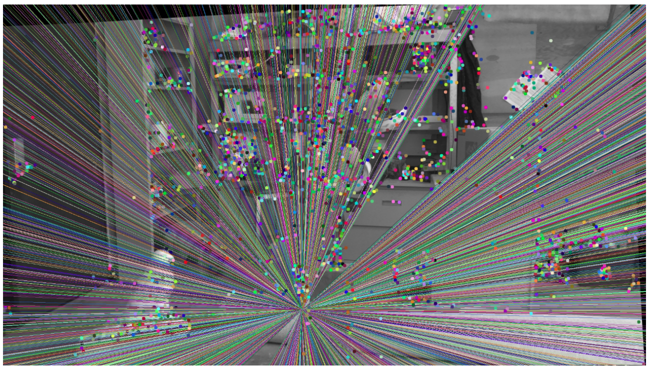
The first step applies the perspective transform to get the horizontal epipolar lines. The homography matrices are estimated. After that, the epipolar lines and the feature points are plotted.

```
Processing chess images
-----------------------------------

Fundamental Matrix
--------------------
[[ 1.39588969e-07  6.54148662e-07 -6.60653904e-04]
 [ 5.31791515e-07  9.79567152e-07 -1.17184953e-03]
 [-3.28198089e-04 -9.15800386e-04  1.00000000e+00]]

Essential Matrix
------------------
[[-0.56916942  0.78721262 -0.23598064]
 [ 0.80764587  0.58412259  0.00929455]
 [ 0.0503304   0.06720682 -0.00531622]]

The Essential matrix is decompposed into the following:
-----------------------------------------------------------
-- Camera 1 --

Rotation Matrix:
 [[ 0.80508601  0.59219909  0.03371574]
 [ 0.55418829 -0.77123965  0.31315291]
 [ 0.21145178 -0.23343016 -0.94910405]]

Translational Vector:
 [-0.02560484 -0.08014088  0.99645463]

-- Camera 2 --

Rotation Matrix:
 [[-0.81254597 -0.58267625  0.01604464]
 [-0.57753731  0.80104531 -0.15740733]
 [ 0.07886503 -0.13716707 -0.98740341]]
```

```
Translational Vector:
 [ 0.02560484  0.08014088 -0.99645463]

Homography Matrices:
--------------------
H1:
[[-1.18135491e-03 -3.51950684e-03  3.47719690e+00]
 [ 2.89420259e-04  1.02352671e-03 -1.07386547e+00]
 [ 4.77487060e-07  1.09051920e-06 -1.23980227e-03]]
H2:
[[ 8.18105938e-01 -5.73246746e-01  5.50498770e+02]
 [-2.48497623e-01  1.39517932e+00 -3.79123649e+02]
 [-8.56608953e-04  6.00225805e-04  4.24639837e-01]]
```

1.2.3 Correspondence

The concept of the matching window is used to obtain the disparity between the images



1.2.4 Compute Depth image