Visual Odometry Report- ENPM 673

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1 Setup

The images from the dataset are converted from the Bayer format to recover color, using the demosaic function with GBRG alignment.

Figure 1: Default image in Bayer format.

Figure 2: Color extracted using demosaic.

Following this, the camera model parameters are read. The image is then undistorted using these model parameters.

Figure 3: Undistorted Image.

2 Feature detection and matching

The next step is feature detection and matching. This can be used to determine the displacement of the feature across two frames. Here SURF features have been used, along with the standard pipeline for feature matching from MATLAB.

Figure 4: Feature matching using SURF features.

3 Fundamental Matrix Calculation

Once the feature matching is done, the fundamental matrix is found for each pair of frames. This is the extrinsic matrix which denotes the transformation between the two images. The fundamental matrix is found by running MSAC on the matched features to get the inliers . The 8-point formula for the fundamental matrix is then used on the inliers from the MSAC to determine the fundamental matrix using the following equation:

$$Af = \begin{bmatrix} \hat{x}'_1\hat{x}_1 & \hat{x}'_1\hat{y}_1 & \hat{x}'_1 & \hat{y}'_1\hat{x}_1 & \hat{y}'_1\hat{x}_1 & \hat{y}'_1\hat{y}_1 & \hat{y}_1{}' & \hat{x}_1 & \hat{y}_1 & 1 \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \end{bmatrix} * \begin{bmatrix} f_1 \\ f_2 \\ f_3 \\ f_4 \\ f_5 \\ f_6 \\ f_7 \\ f_8 \\ f_9 \end{bmatrix} = 0 \tag{1}$$

The Fundamental Matrix can be constructed as follows:

$$F = \begin{bmatrix} f_1 & f_2 & f_3 \\ f_4 & f_5 & f_6 \\ f_7 & f_8 & f_9 \end{bmatrix} \tag{2}$$

4 Essential Matrix from Fundamental Matrix

The fundamental matrix is then converted to the essential matrix as follows:

$$E = K' * F * K$$

Where, K is the intrinsic Camera Matrix, F is the Fundamental Matrix. The Rotation and Translation Matrices are determined by decomposing the essential matrix as follows:

$$[U, S, V] = svd(E)$$

The Rotation can be estimated as follows:

$$R = U * W * V'$$

Where,

$$W = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

The translation can be determined as follows:

$$T = U * Z * U'$$

Where,

$$W = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \tag{4}$$

This results in four possible position and orientation combinations from which the correct combination has to be chosen for every pair of frames. We then implemented the triangulation function from the relativeCameraPose function in MATLAB to determine the correct pair of Rotation and Translation per pair of frames.

5 Plotting Trajectory

An origin point is incrementally rotated and translated based on the results from the essential matrix decomposition as follows:

$$R_{pos} = R * R_{init}$$
$$P = P_{init} + T * R_{pos}$$

Where R_{init} is the previous rotation, R is the current Rotation, P is the current position of the camera and P_{init} is the previous position.

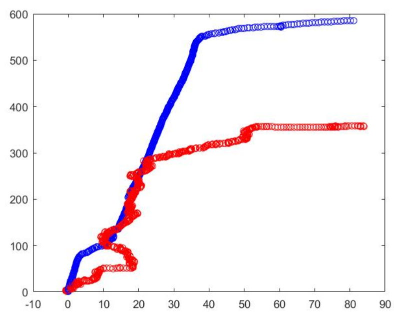

Figure 5: Trajectory plotting.

In figure 5, The blue trajectory is the trajectory calculated using the fundamental matrix from the inbuilt MATLAB function estimateFundamentalMatrix. The Red trajectory is the trajectory determined by implementing the 8-point algorithm. Since the MATLAB function has a better implementation of RANSAC to remove matching outliers, the trajectory is a much better representation of the ground truth.