Epipolar Geometry and 3D reconstruction

CV ASSIGNMENT 3

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Contents

Objective

The following report discusses the construction of Fundamental Matrix, given the corresponding match points are given for two different views of the same space in 3D. Further, the epipolar lines are constructed in second image for its corresponding point in first image/view. The second part discusses the construction of 3D space, given the camera matrices are known.

Fundamental Matrix

The Fundamental Matrix is constructed by following 8-point algorithm. The algorithm requires the correspondences to be known in two views of 3d scene. Figure 1 and Figure 2 shows the corresponding matching points in two different views of the same scene.

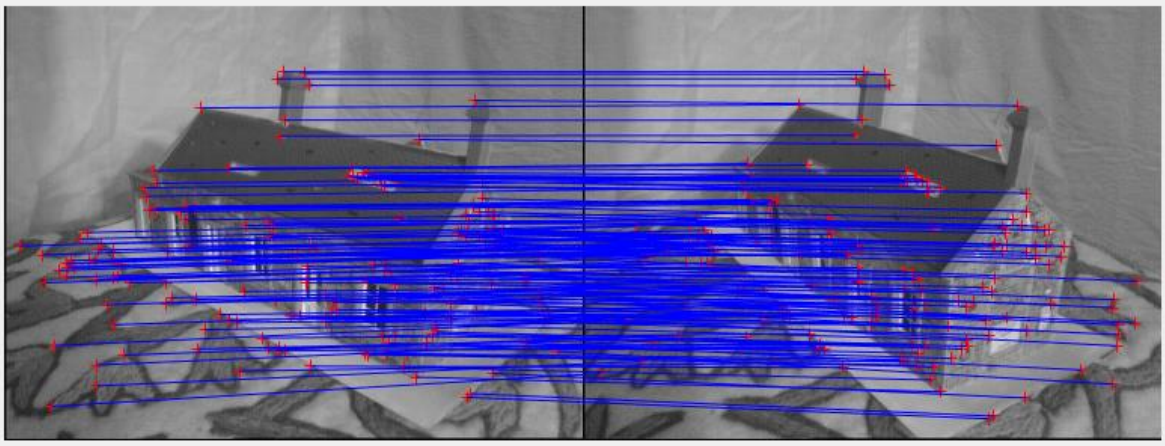


Figure 1

Figure 2

The algorithm works by computing A matrix from the equation:

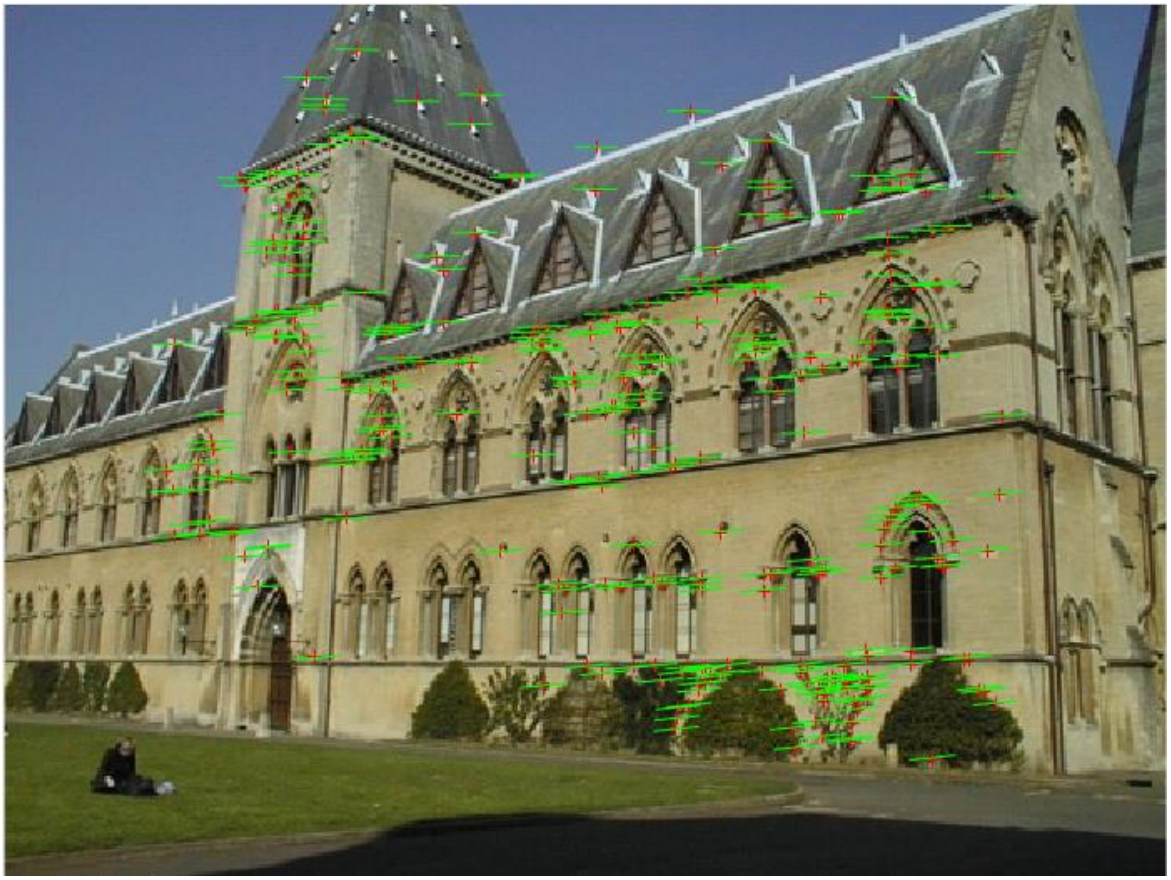
$$Af = 0$$

Where A is m x 9 matrix (m is the number of corresponding pairs of points in the two views) and f is a 9 x 1 vector representing the elements of the matrix. A is fully dependent on the coordinated of the corresponding points and hence can be calculated from the given information.

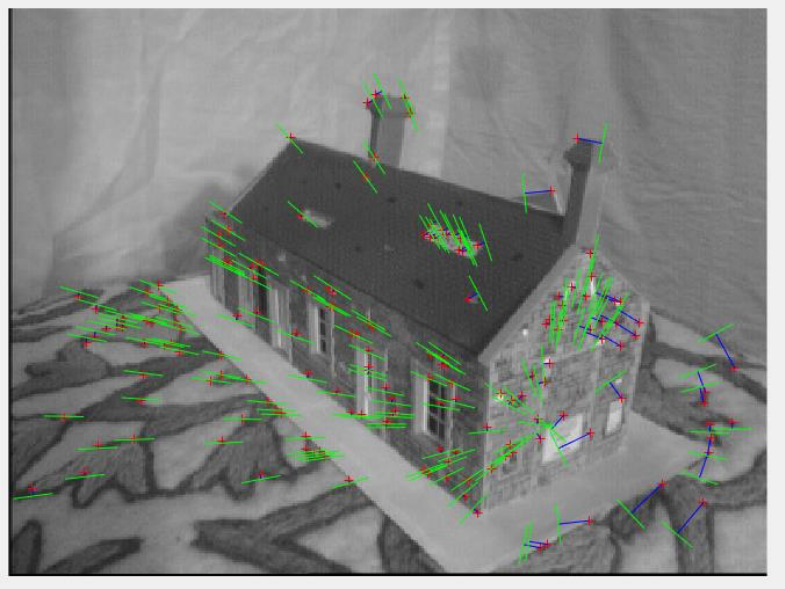
The equation is solved using singular value decomposition method. Further, to ensure that F is a rank 2 matrix, SVD is run on F (reshaped from f as 3 x 3 matrix) and smallest singular value of F is made 0 and F is recomputed by multiplying individual components U, S and V'.

Epipolar Lines and Epipolar Point

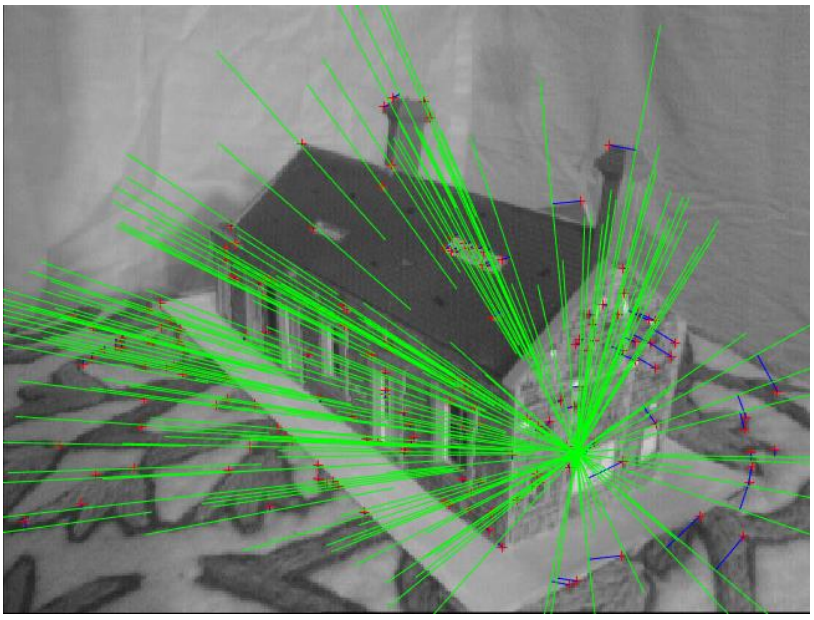
The epipolar lines are then computed using the Fundamental matrix and are shown below.



Green lines represent the Epipolar lines and red cross represent the match points



All the epipolar lines must pass through the epipole point which is the point of intersection of the line connecting two reference points and the image planes. All the epipolar lines converge to that point as shown below:



Although, as it can be seen from the image, not all the lines pass through the matched points, which should be the case ideally. This can be accounted to reasons like measurement errors, diffraction/refraction of light and discretization of continuous space.

Residuals:

These errors are measured in terms of residuals and are calculated as follows:

Residual = (Sum of squared distance of all the points from line) / (Total number of pairs)

Residual for house image = 26.4013

Residual for library image = 0.1792

It is also given as: x' F x

Reconstruction of 3d Space

The 3D space is reconstructed from the two views by employing the information of matched points between two spaces long with the camera matrices of the two reference points by using linear triangualation.

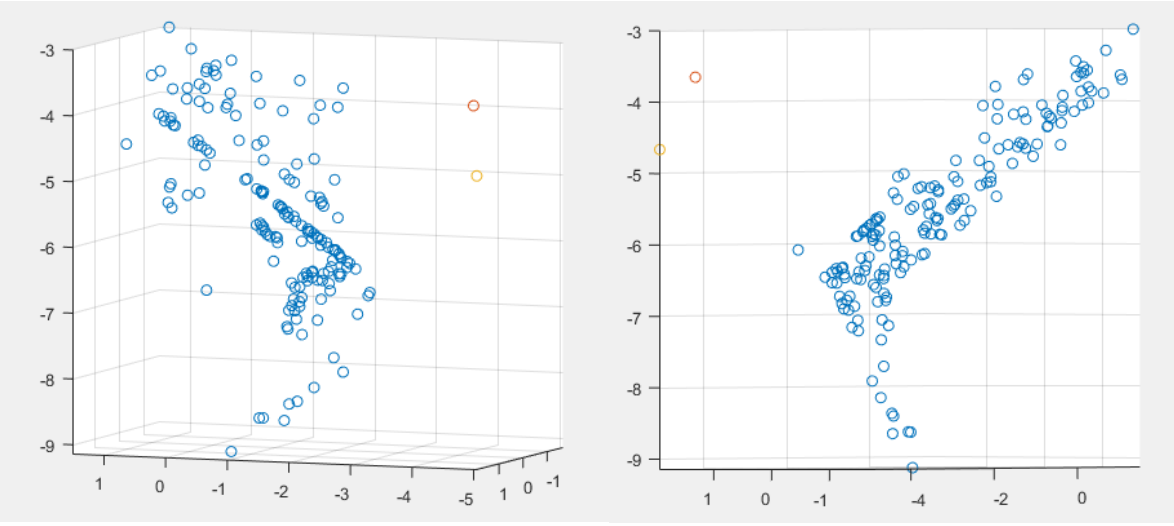
Again, it requires to solve the equation

$$A X = o$$

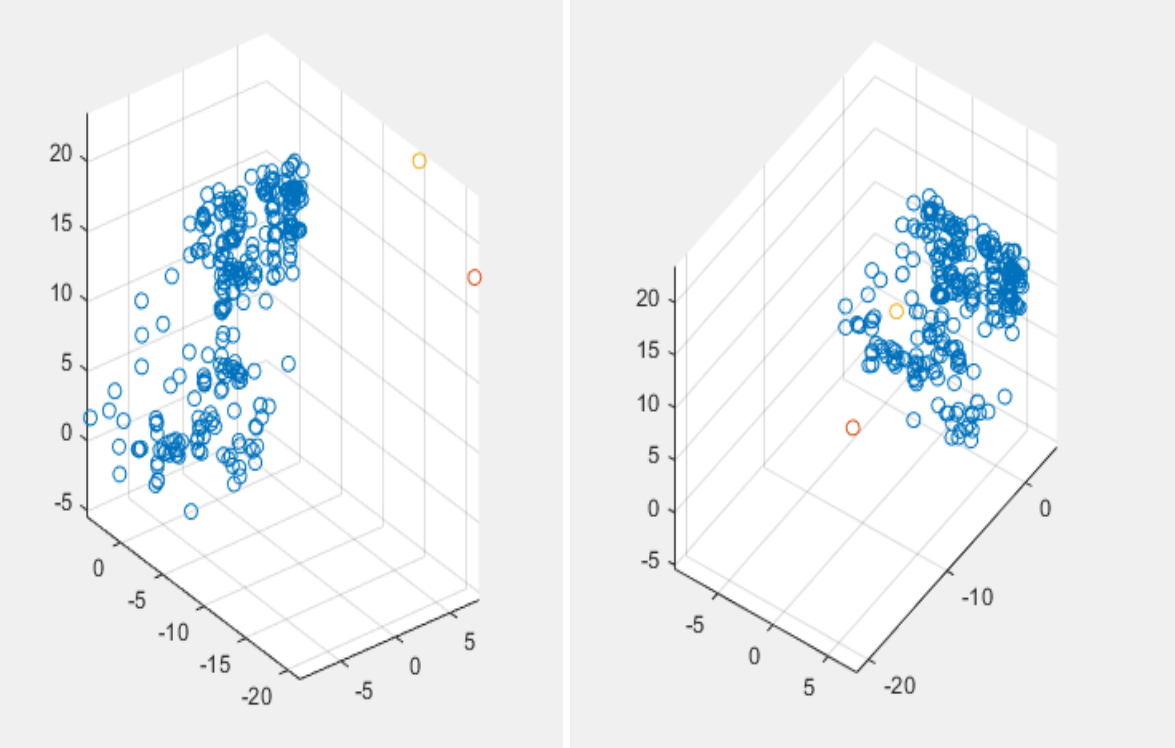
Where A is a 4 x 4 matrix dependent on camera matrices and the corresponding location of matching points in image plane.

SVD is used to solve the equation and all the homogeneous real word coordinated are computed for each point. The centers' coordinates are computed by employing SVD on camera matrices.

The results are shown below:



3D view of the House Image



3D view of the Library Images

An attempt to construct the view in 2D is made such that the z values correspond to the intensity values for the position x, y.

The following result is obtained for library image. Since there are only limited match points, it is not feasible to comprehend it as the scene of library.