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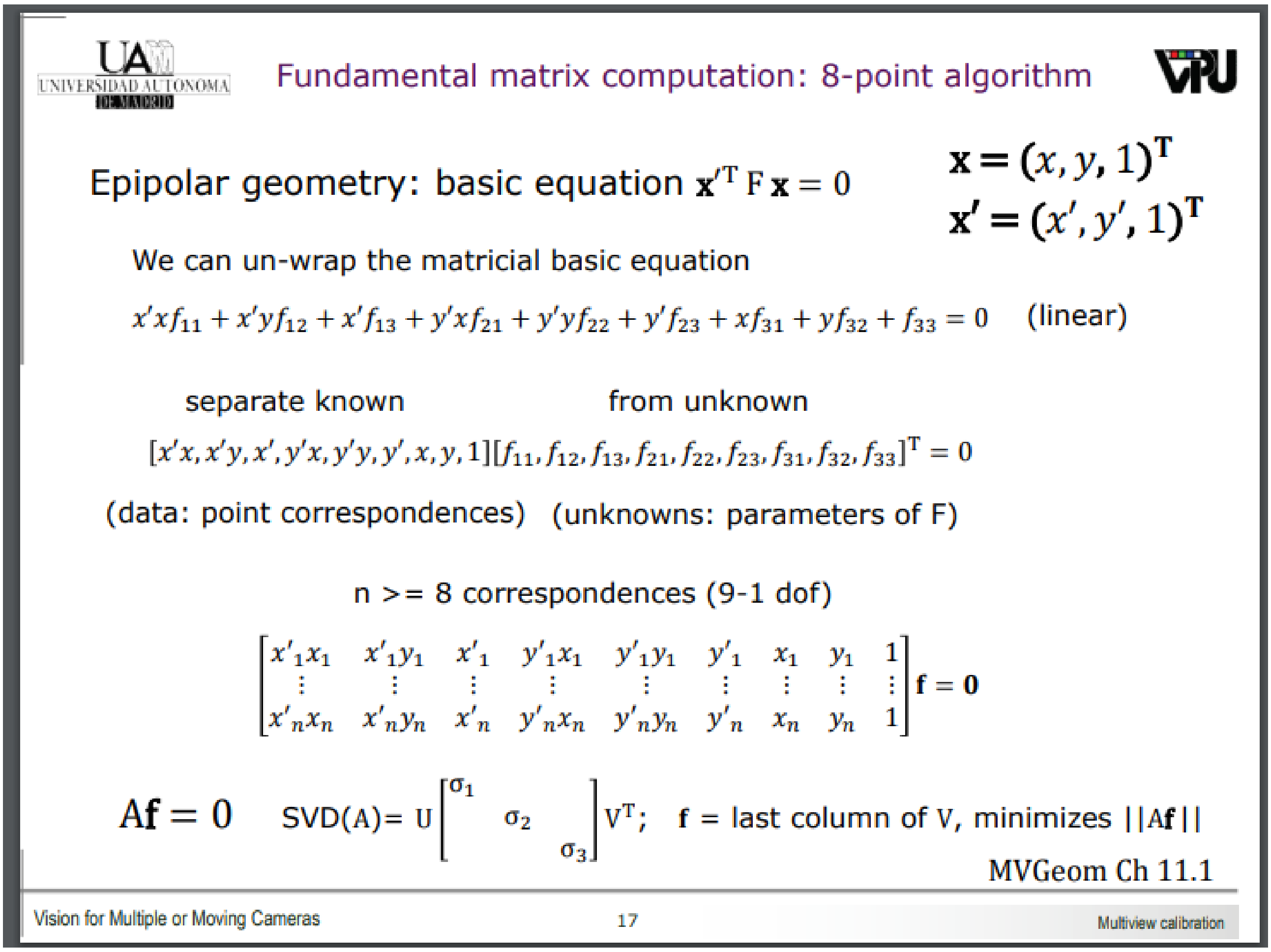
09.04.2023

Lab Ass. VI: Two-view projective calibration and 3D reconstruction

The objective of this lab session is to present the student with various techniques related to the application of several concepts of two-view projective geometry to the field of camera calibration and 3D reconstruction. For the understanding of the functions that are proposed, it is essential to navigate through the MatLab help.

1. **Visual interpretation of the epipolar geometry (epipolar lines)**
   The vgg_F_from_P function computes the fundamental matrix from the two camera matrices. The fundamental matrix is the algebraic representation of epipolar geometry. In the following we derive the fundamental matrix from the mapping between a point and its epipolar line, and then specify the properties of the matrix.



The fundamental matrix F relates corresponding points in two views of a scene and can be computed using point correspondences in both images. One important property of the fundamental matrix is that it has rank 2 if and only if the epipolar lines associated with the point correspondences are linearly independent.

In other words, for a fundamental matrix F to have rank 2, the epipolar lines for each corresponding point in one image must not be collinear in the other image. This condition is critical because a fundamental matrix of rank 2 can be used to determine the 3D structure of the scene from two views, while a fundamental matrix of rank 3 or higher cannot.

The condition that the epipolar lines must fulfill for the computed fundamental matrix for the two images to have rank 2 is that the epipolar lines corresponding to each pair of matching points in one image should not be collinear in the other image. So, if we have two images of a scene and we identify a point in one image and its corresponding point in the other image, the line connecting these two points in the first image should intersect the line connecting the corresponding points in the second image at a unique point, except in the case where the two lines are parallel. If the lines are parallel, it means the corresponding points lie on an infinite line in the other image. However, in general, the epipolar lines should not be parallel or intersect at the same point for multiple point correspondences, as this would mean that the rank of the fundamental matrix is not 2.

From the images and lines it is visible that the rank of the matrix here is two and to check it with code I plotted out the rank of the F matrix (The rank_of_F =   2).

My estimation for the point is (254.3057, 189.2086) in the images.

2. **Estimation of the fundamental matrix from point correspondences between two cameras, and projective reconstruction**

I ran the code and visualized the 3D scene with the projection of the points in both cameras. I've got the following three figures.

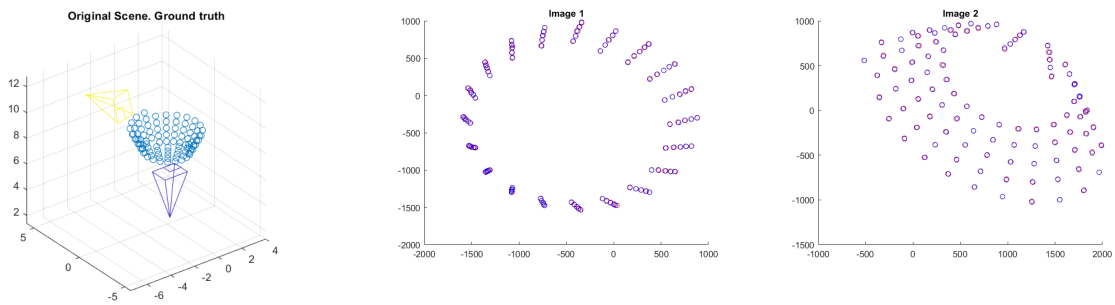


Figure 1 Ground truth scene and reprojection of the points in the two cameras

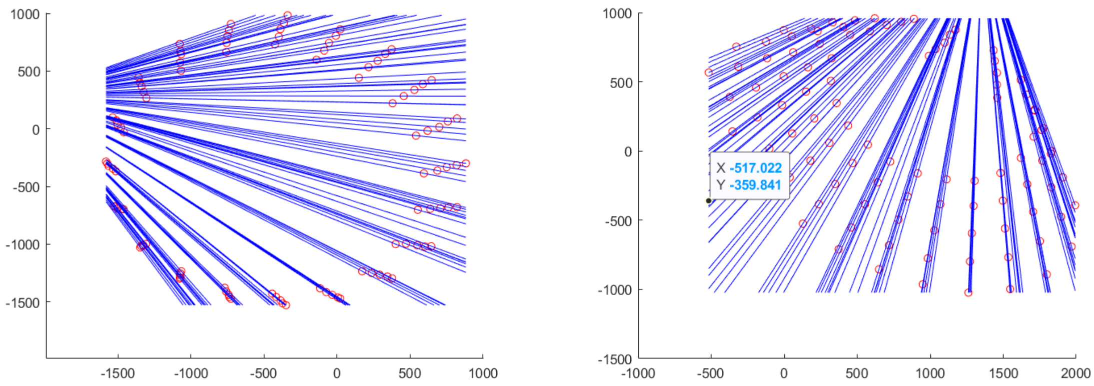


Figure 2 Epipolar lines in the two reprojected images

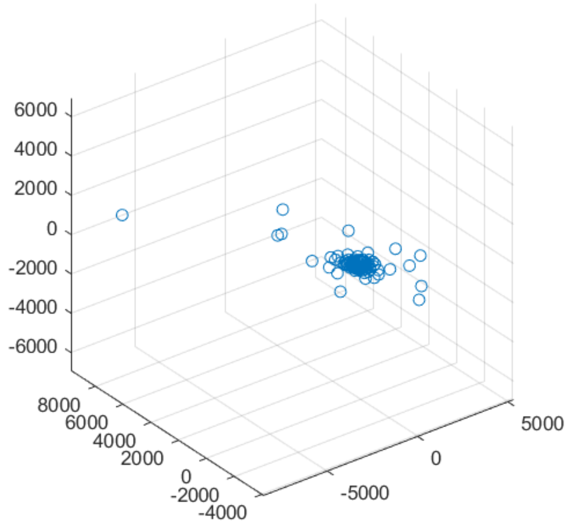


Figure 3 Projective reconstruction

Values for ideal data:
Minimum singular value = 2.6438e-15
Residual reprojection error. 8 point algorithm = 1.6724e-20
Pixel error: mean = [0.00000 0.00000]
Pixel error: std = [0.00000 0.00000]

Values for noisy data:
Minimum singular value = 0.057054
Residual reprojection error. 8 point algorithm = 16.6713
Pixel error: mean = [-1.17420 0.60470]
Pixel error: std = [4.50151 3.39020]