4 Computer Vision – Pierre Beckmann

4.1 Line fitting with RANSAC

Implementing the Ransac algortihm for line fitting we got very satisfying results using 300 iterations.

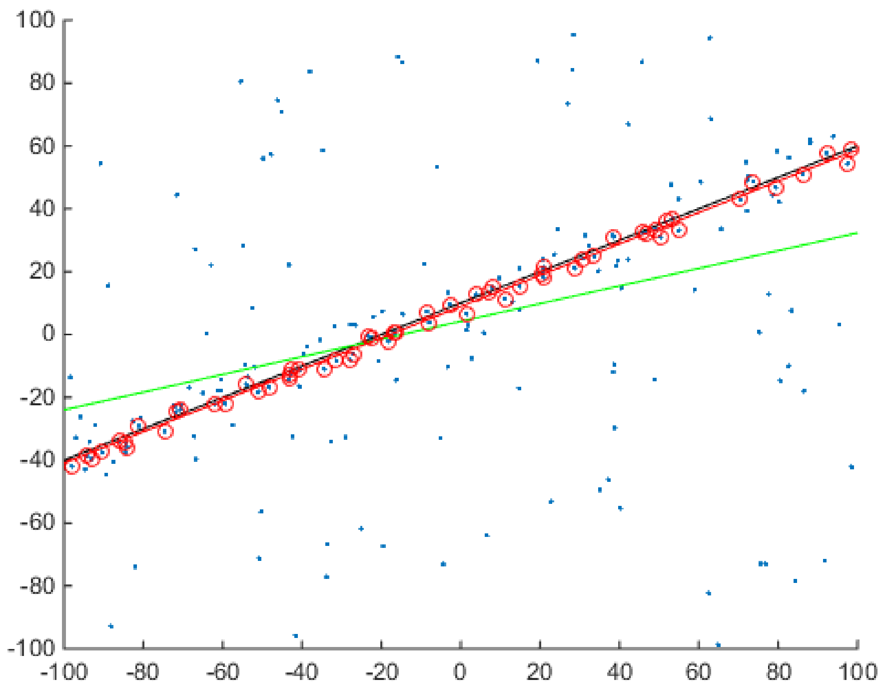

Figure 1: **Ransac Line Fitting.** In blue we have the points and in black the real model. Least square fitting results in the green line whereas Ransac gives the red line. The red-circled points are the inliers of the red line.

4.2 Fundamental matrix

We computed epipolar geometry between pairs of images using the eight point algorithm. The points were normalized and the singularity constraint was enforced on F after denormalizing it. Singular F matrix was called Fh. Following results were obtained on the second dataset.

$$\mathbf{F} = \begin{bmatrix} -0.0000 & -0.0002 & 0.0773 \\ 0.0002 & -0.0000 & -0.0951 \\ -0.0734 & 0.0967 & -1.9375 \end{bmatrix}, \mathbf{Fh} = \begin{bmatrix} -0.0000 & -0.0002 & 0.0773 \\ 0.0002 & -0.0000 & -0.0951 \\ -0.0734 & 0.0967 & -1.9375 \end{bmatrix},$$

$$\mathbf{Fh\text{ - }F} = 1.0e-06 * \begin{bmatrix} 0.2258 & 0.0580 & 0.0005 \\ 0.0416 & -0.0107 & -0.0001 \\ 0.0001 & 0.0000 & 0.0000 \end{bmatrix}.$$

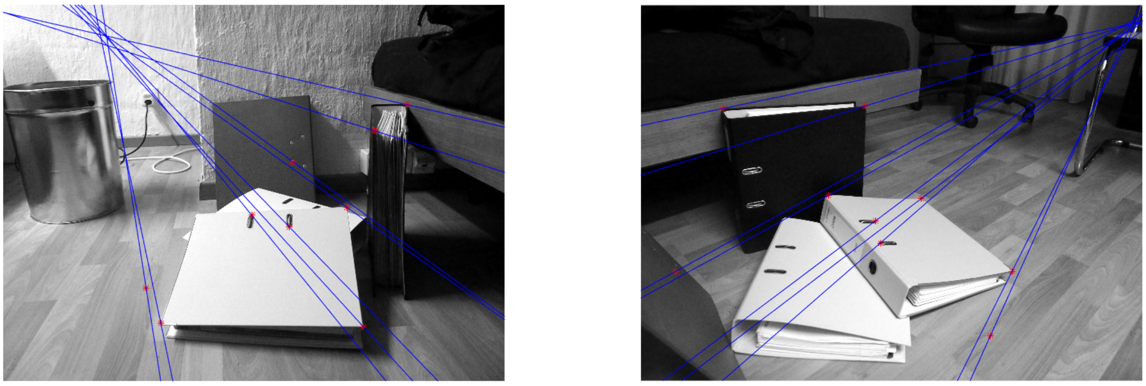

Figure 2: **Using the fundamental F matrix to visualize epipolar geometry.** Correspondences are in red and the epipolar lines in blue. Epipoles are found at the intersection of the epipolar lines. Without enforcing the singularity the epipoles are not clearly distinguishable because the epipolar lines don't cross in the exact same point.

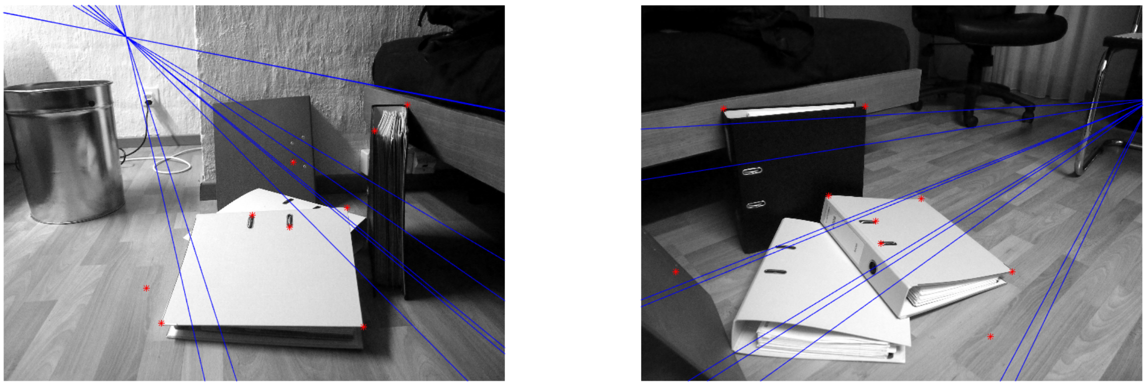

Figure 3: **Using the computed singularity constraint enforced Fh matrix to visualize epipolar geometry.** Correspondences are in red and the epipolar lines in blue. Epipoles are found at the intersection of the epipolar lines. This time all the epipolar lines interesct in the same epipole but the epipolar lines don't cross their corresponding points perfectly.

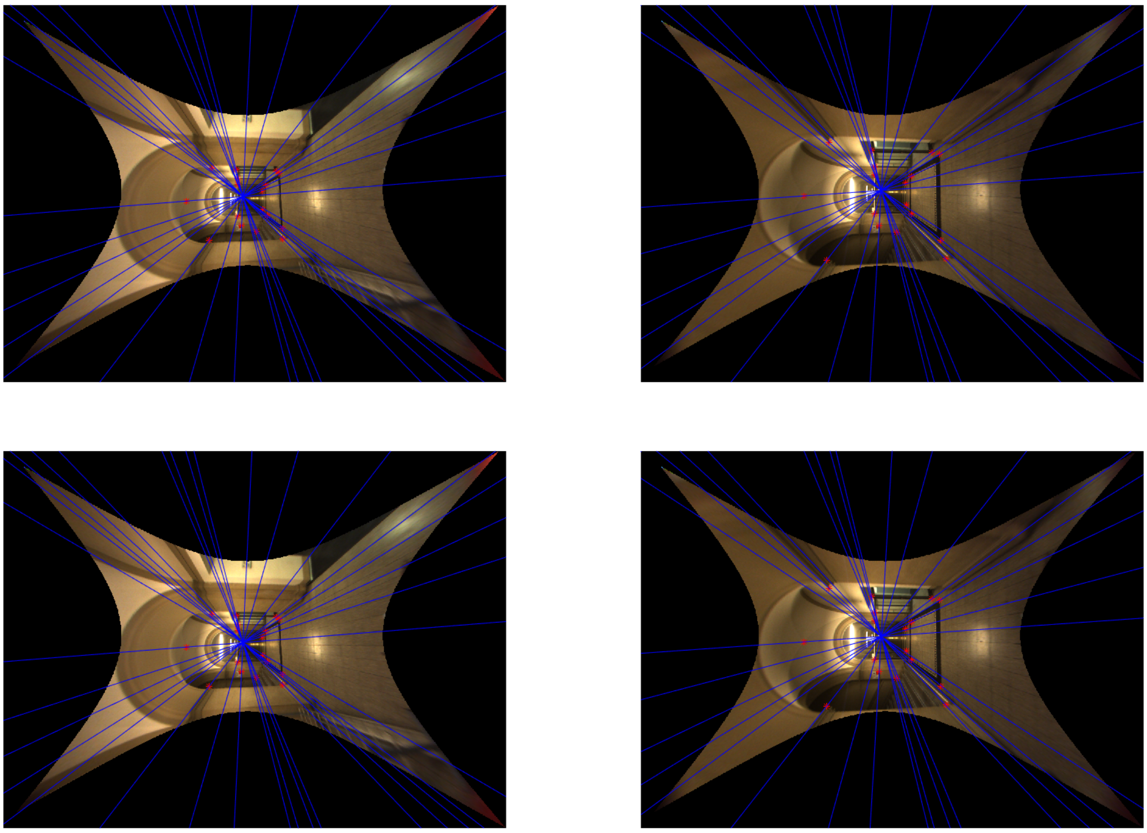

Figure 4: **Epipolar geometry for dataset1.** Upper pictures using F and pictures bellow using Fh. Correspondences are in red and the epipolar lines in blue. Epipoles are found at the intersection of the epipolar lines. For dataset 1 matrices F and Fh give the exact same results.

4.3 Essential matrix

Using the camera calibration with the K matrix we used another eight point algorithm to compute the essential matrix. Points were normalized and singularity was enforced on E to obtain Eh. Using the formula $F = K^{-T}EK^{-1}$ we computed the corresponding F matrix which was almost exactly the same than the F matrix obtained in previous section (still for dataset 2). The difference could come from the K matrix which is not experimental and can't be perfectly accurate.

$$F - K^{-T}EK^{-1} = 1.0e - 03 * \begin{bmatrix} -0.0000 & 0.0000 & -0.0000 \\ 0.0000 & 0.0000 & -0.0003 \\ -0.0000 & -0.0009 & 0.1318 \end{bmatrix}.$$

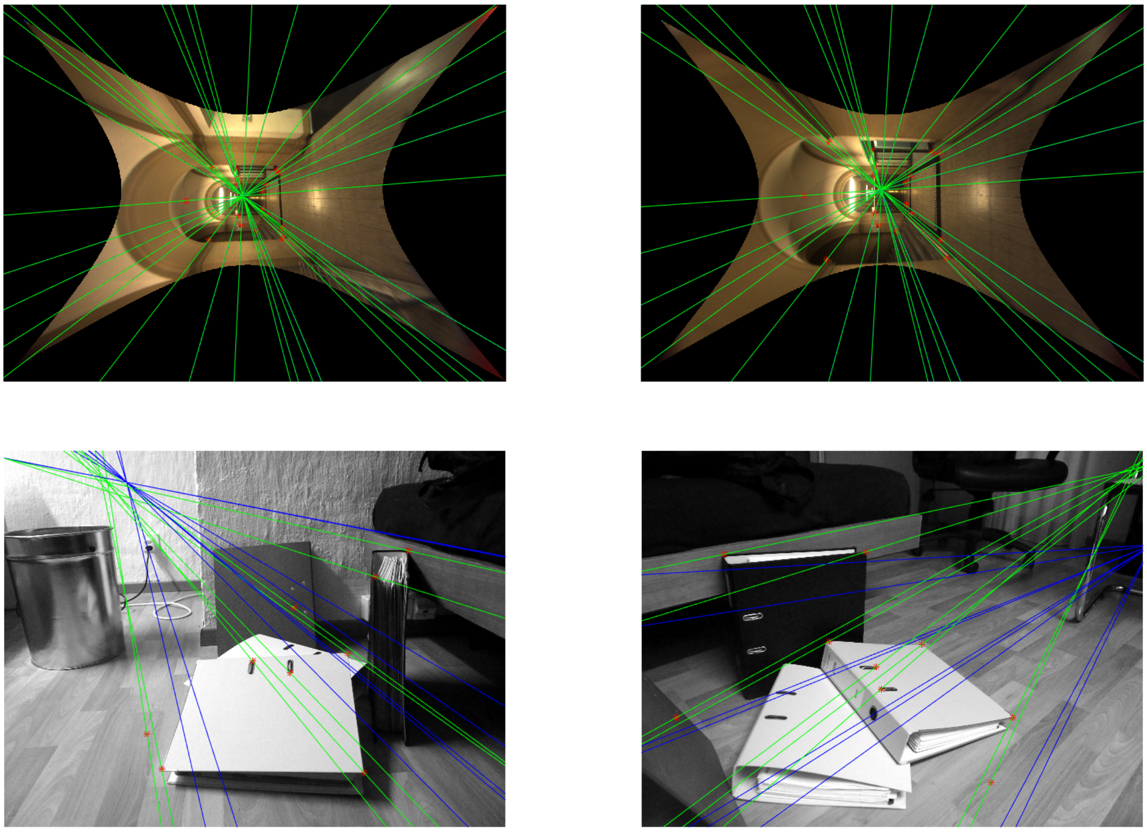

Figure 5: **Epipolar geometryusing the essential matrix.** Upper pictures using dataset 1 and pictures bellow using dataset 2. Correspondences are in red and the epipolar lines found using Fh are in blue and in green when using F. Epipoles are found at the intersection of the epipolar lines. For dataset 1 the green and blue lines are perfectly superimposed so there seems to be no significant difference between F and Fh.

4.4 Camera matrix

Taking the first camera matrix P to be the origin of the camera coordinate system we computed the correct P' from the four possible solutions obtained using the essential matrix decomposition to R and t. This was done by using a triangulation function and making sure that the 3d points X have a positive z value: $X(3) > 0$ and that $[P'X](3) > 0$ for the coordinates in second camera.

The points were normalized: $nnxs = K \backslash xs$ and we made sure that the R matrices follow the right hand rule: $R = R * det(R)$ (this way we force the det(R)=1).

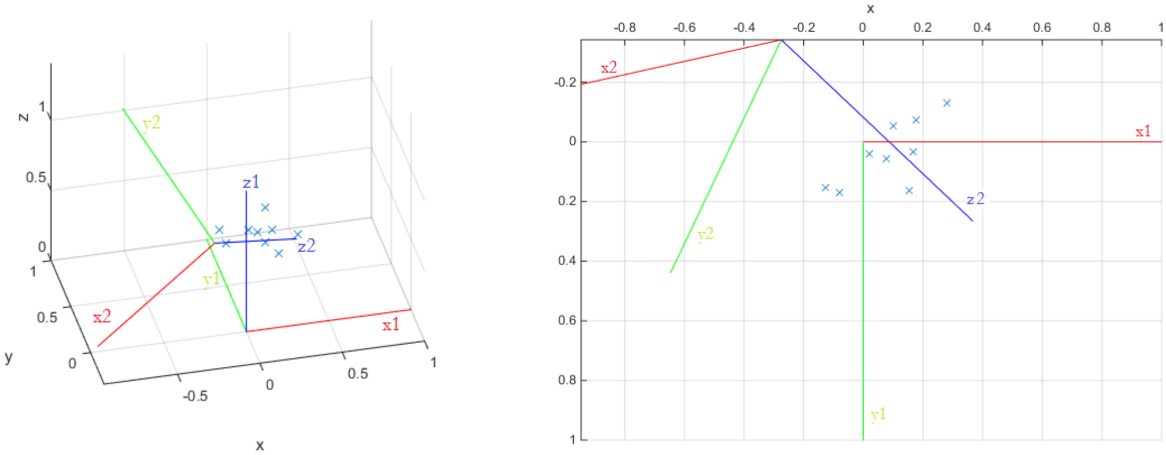

Figure 6: **Computing the two camera matrices P1 and P2 for dataset 2.** The points are in blue x's and the axis of the cameras are shown. On the right we look at the space in the x y plane. If you look at fig.3 you can easily match the points of the image on the left to the blue x's in this figure on the right. Note that z2 seems to be coming from the epipole on fig.3. Overall we seem to have chosen the good P' (P2 in this case) because the points are in postive z for both frames (fig on the left) and seems to agree with precedent results.

4.5 Feature extraction and matching

Using vlfeat we computed matches between the two pictures of dataset 1.

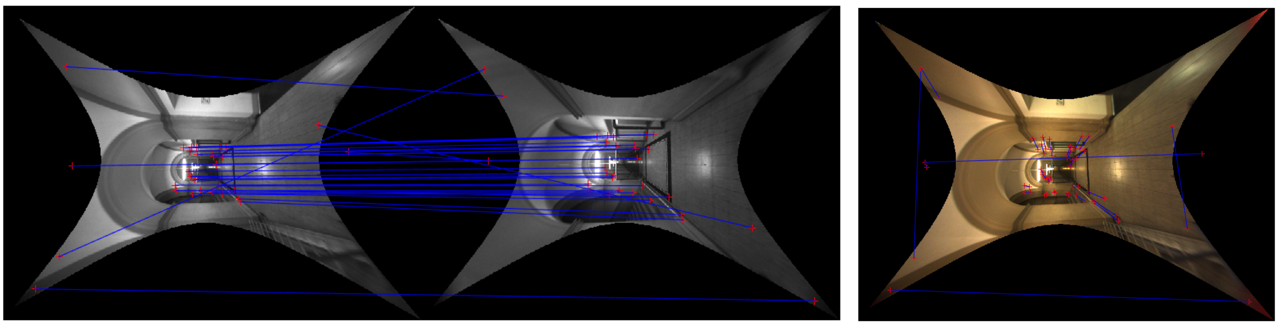

Figure 7: **Feature extraction and matching using vlfeat.** On the left we have both pictures side by side with the matches connected in blue. On the right we draw both matches on the same picture to give a sense of motion of the points from one image to the next.

4.6 8-point RANSAC

We implemented and used adaptive RANSAC to remove the wrong matches of the vlfeat matching and computed the corresponding F matrix. The number of iterations n is being updated dynamicly $n = round(log(1-p)/log(1-r^N))$, with p the desired confidence, N the nuber of samples and r the inlier ratio.

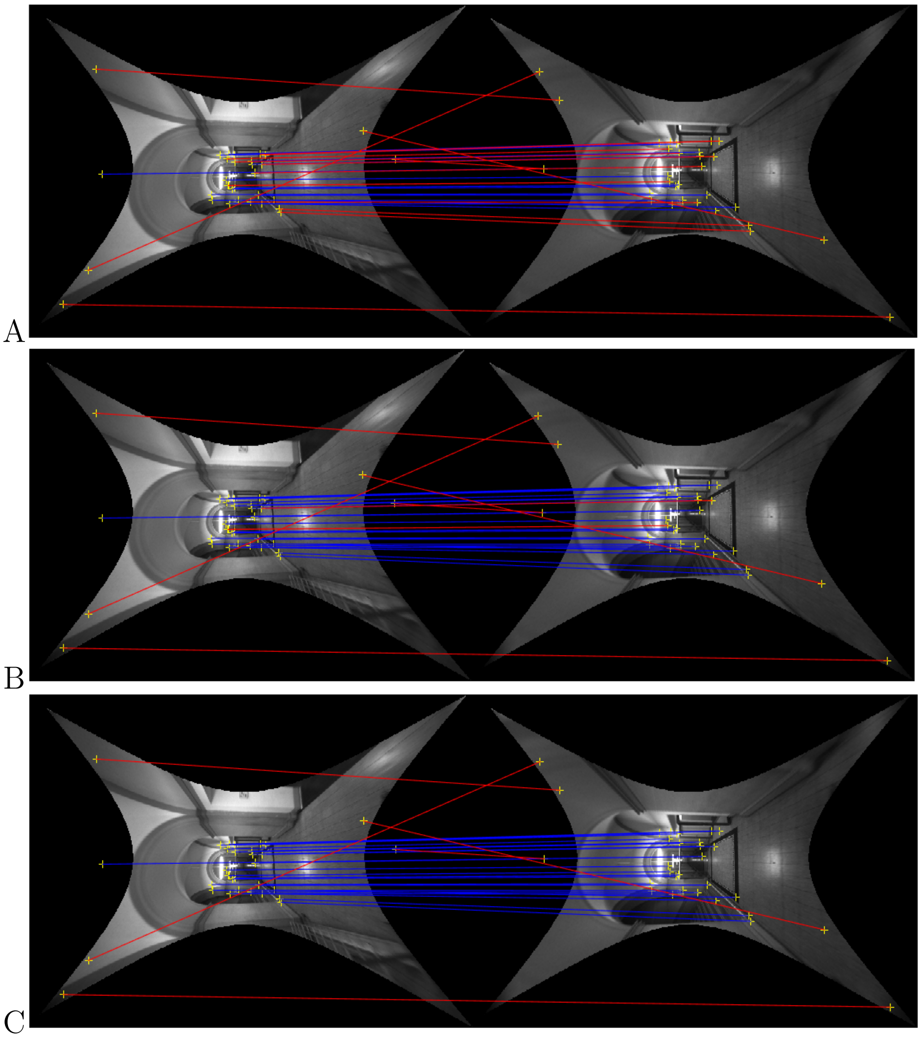

Figure 8: **8-point RANSAC: plotting outliers and inliers with different thresholds.** All the points are in yellow, the inliers are connected by blue lines and the outliers are connected by red lines. A: threshold of 1 pixels, 604 iterations used, inlier ratio of 57%. B: threshold of 4 pixels, 38 iterations used, inlier ratio of 80%. C: threshold of 8 pixels, 20 iterations used, inlier ratio of 86%.

Now we check the epipolar geometry with obtained F matrix.

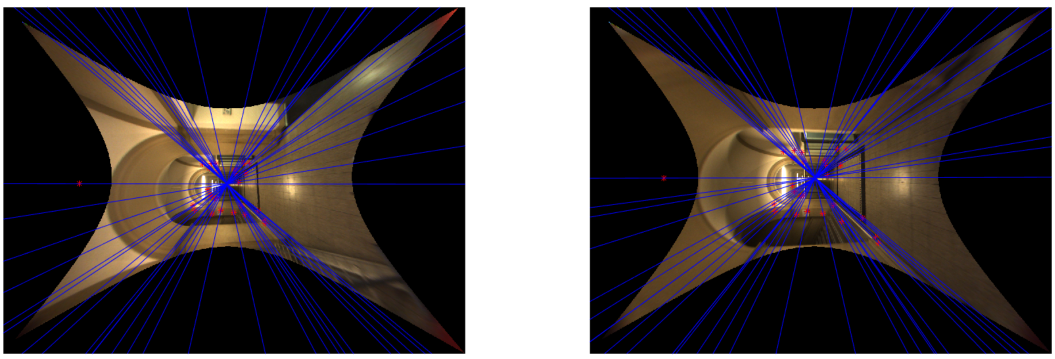

Figure 9: **Epipolar Geometry using F matrix from RANSAC.** Correspondences in red and epipolar lines in blue. The obtained matrix seems to be good as it correctly crosses the points and the epipolar lines cross in the epipole.