Autonomous Robotics
Practical Session #1 «Projective Reconstruction»

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1. Simulate a simple 3D scene and stereovision system, assuming that all the parameters are known (intrinsic and extrinsic parameters). Compute the resulting images (projections of the scene onto the two camera planes).

A simple surface is given as 3D shape and the following parameters were set up for a given camera. The camera has focal length of 200, and center at 500 and 500. The image size is 1000×1000. The camera is looking toward the surface from $[-25, -25, 70]$ coordinate and angles $[5, -5, 75] \times \left(\frac{\pi}{180}\right)$. The 3D object is shown in Fig.1.a(left) and captured image in Fig.1.b(right).

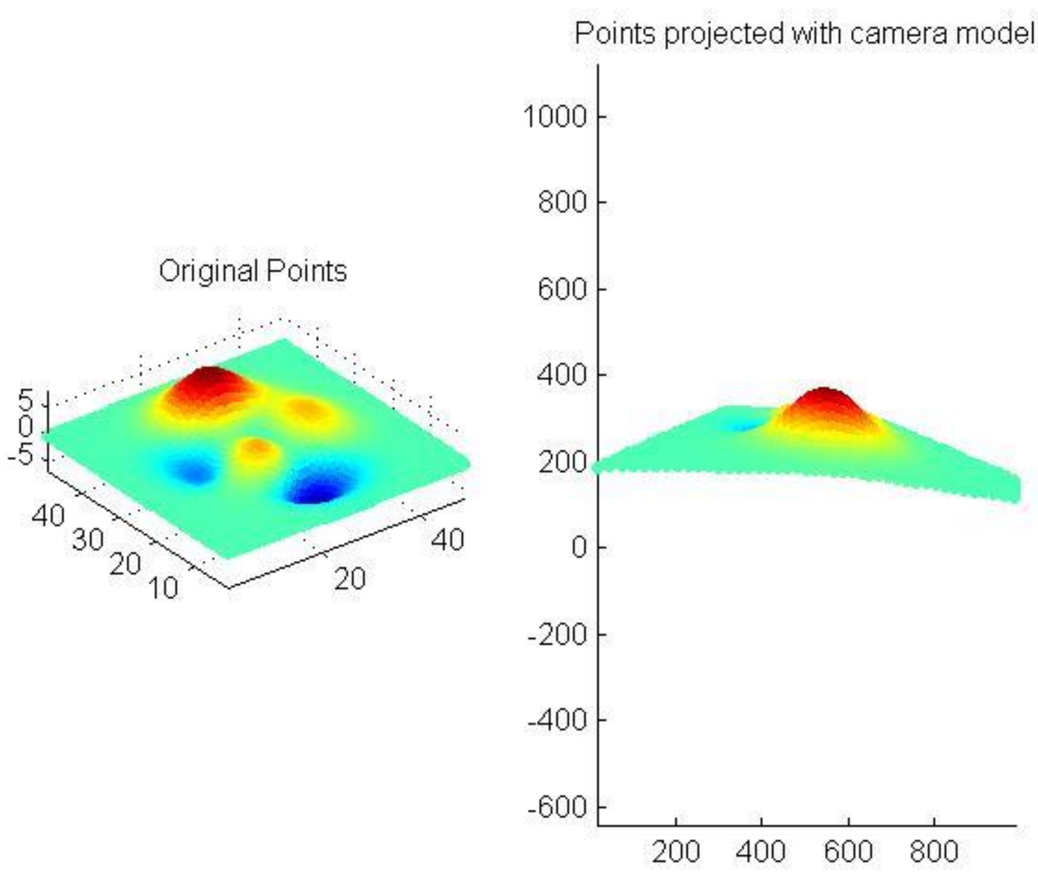


Fig.1 (a) 3D surface used as object (b) projected image into camera sensor for a given point

2. Compute the fundamental matrix from the known parameters and the following equations : http://en.wikipedia.org/wiki/Fundamental_matrix_(computer_vision).

See script “demo_F_matrix.m”, for a given set of calibration parameters and two sets of corresponding features and fundamental matrix is calculated as follows. Alternatively, finding features and matching them can be achieved following process shown in Fig.2-Fig.6.

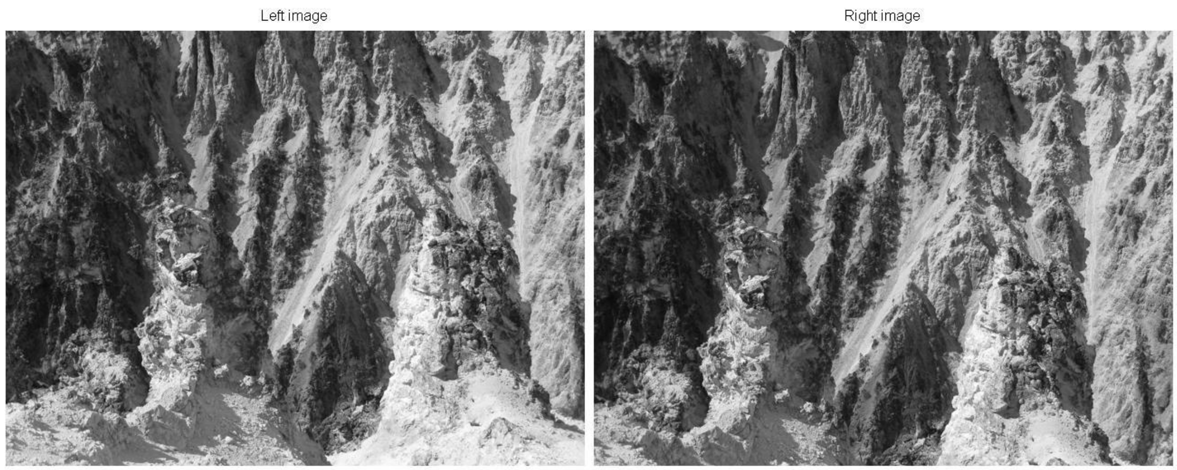


Fig.2 orginal paire of images

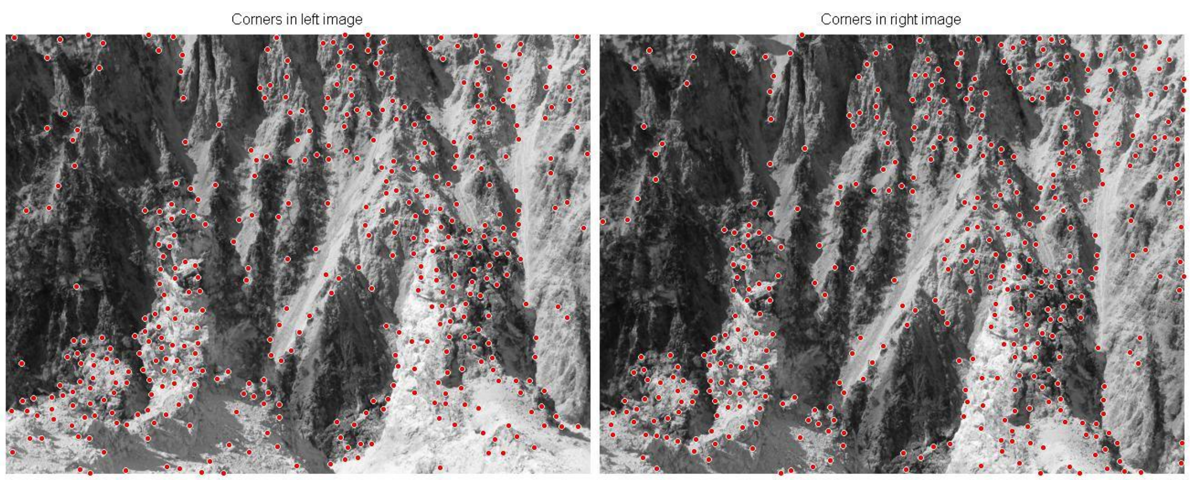
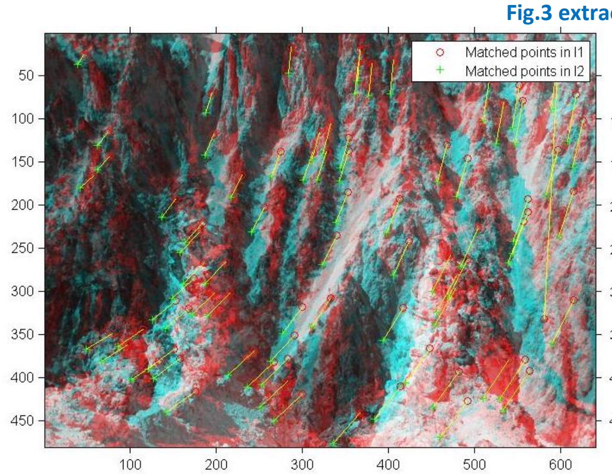


Fig.3 extracted features



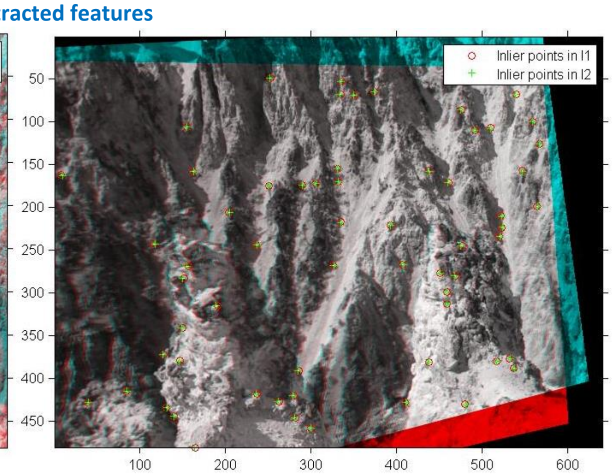


Fig.4 matched features Fig.5 displacement of the second image versus first image

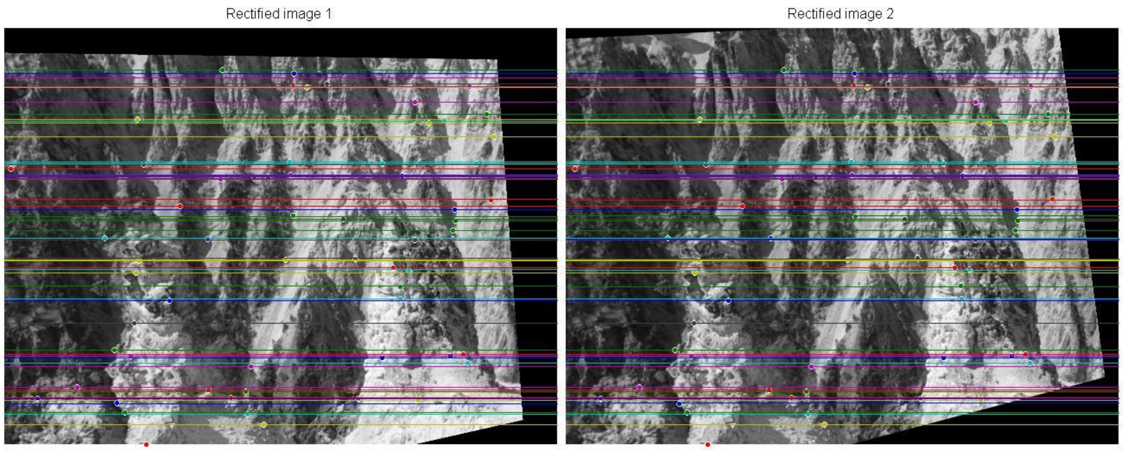


Fig.6 epipolar line between two images

$$E = \begin{bmatrix} -0.0000 & -0.0000 & -0.0024 \\ 0.0000 & -0.0000 & -0.0048 \\ 0.0038 & 0.0039 & -0.0925 \end{bmatrix}$$

3. Estimate the fundamental matrix from the two images (you can use [Salvi's toolbox]).

Two following image is given as an input:

Fig.7 original pair of images

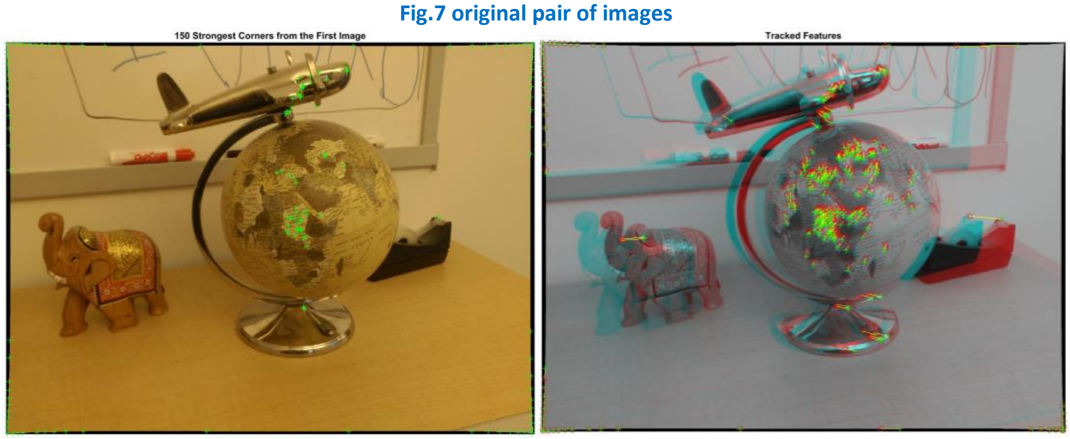


Fig.8 feature finding and feature movement between two images

$$E = \begin{bmatrix} 0.013 & 0.173 & -0.050 \\ -0.03 & -0.001 & -0.998 \\ 0.072 & 0.982 & 0.005 \end{bmatrix}$$

4. Compute the 3D scene from the canonical representation. Comments.

Original Images

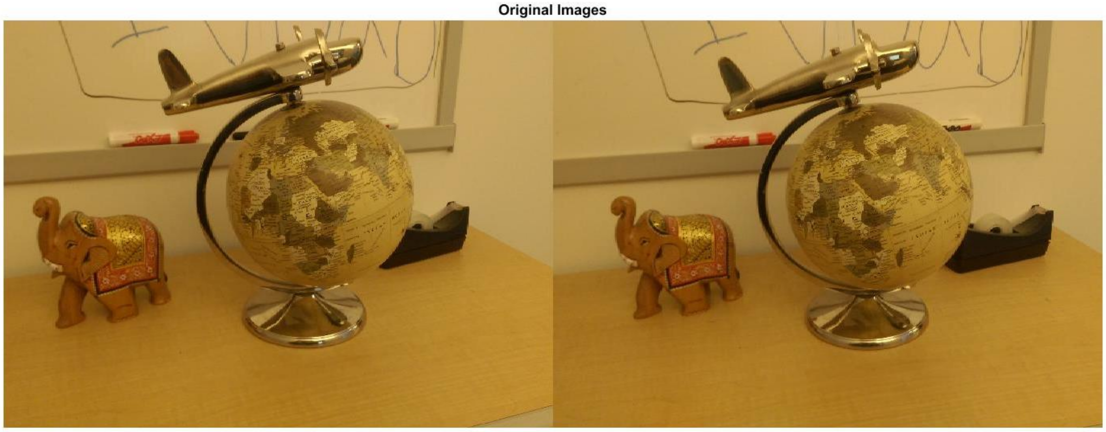


Fig.9 original pair of images

Fig.9 these two above images were combined to make a 3D model. However, a lot of detail is missing in the 3D model. The reason why these details are missing is that only a tiny fraction of the feature points were used to reconstruct the 3points which does not necessarily gives a precise result.

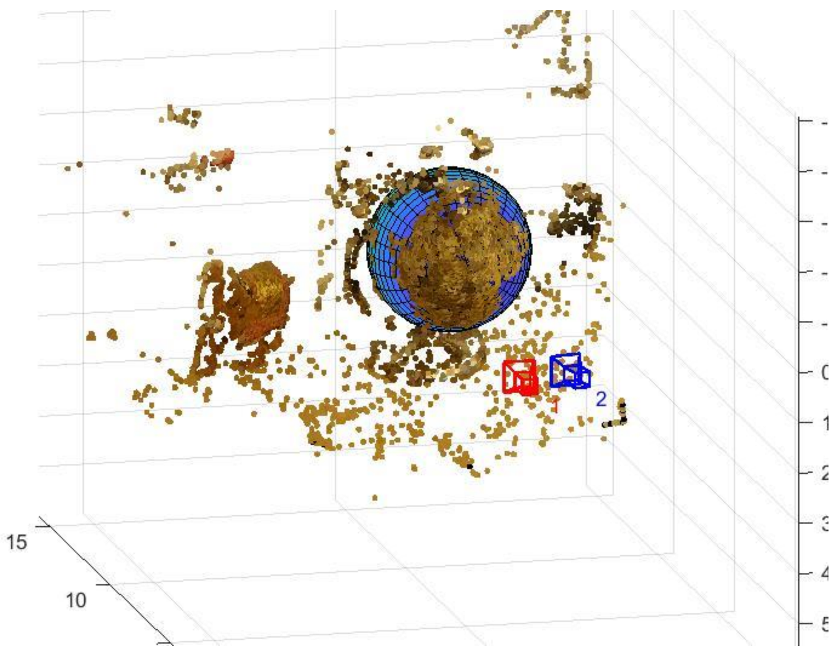


Fig.10 Reconstructed 3D model

5. Compute the residual error (2D error). Comments.

Since we did reconstruction from 2 images it is very three that our fundamental matrix is not precise and a lot of detail is missing. Besides, a quantitative metrics can be calculated uses the same view as original image and using code used in the section 1 to calculate the difference. The more precise reconstruction will be provided in section 6.

6. Refine the 3D estimation through a Levenberg-Marquardt algorithm. Compute the 3D scene and residual error. Comments.

In this section, we have used more images from different view and correct the reconstruction parameters using Levenberg-Marquardt algorithm. The detail input images and final reconstruction is shown in Fig.11 and Fig.12.

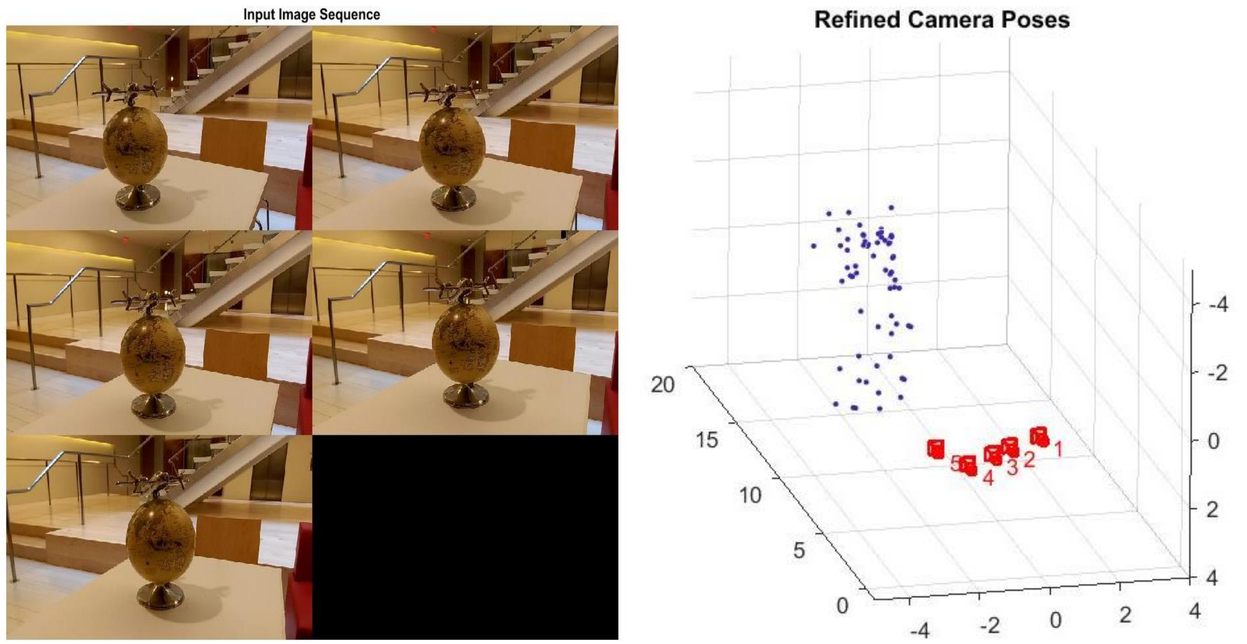


Fig.11(a) original image set for reconstruction (b) initial reconstructed 3D points with camera poses

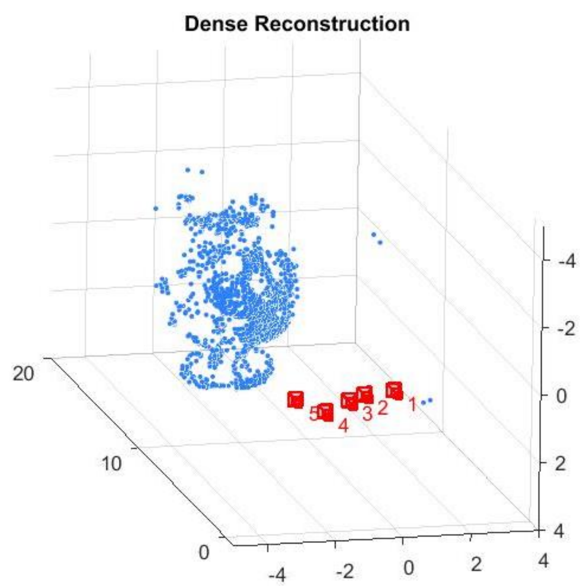


Fig.12 3D object reconstruction after refining 3D points

7. Compare the estimated 3D scene with the initial one (fixed in question 1). Comments.

There is significant difference between initial 3D object and refined 3D object. As seen, the 3D object is completely distinguishable while in the initial version of the 3D object reconstruction the object is not clearly seen and only the points are there.