ECE661: Homework 9

Fall 2014

Deadline : November 25, 2014, 1:30 pm

Turn in your solution via Blackboard. Additional instructions are at [I]

1 Introduction

The focus of this assignment is on projective reconstruction of a scene using stereo images. A 3D reconstruction is called projective if it is related by a 4x4 homography to the real scene. Obviously, this means that what we obtain from projective reconstruction might appear distorted when compared to the actual scene. In practice, depending on how rich the scene structure is and how much prior knowledge one has about the objects in the scene, one may be able to use additional constraints derived from the reconstruction to remove the projective, the affine, and the similarity distortions. In this homework, however, our focus is on just creating a projective reconstruction of a scene.

Take a pair of stereo images with your camera, with no particular constraints on how the second image is recorded vis-a-vis the first, as long as the two views are of the same scene.

2 Tasks

2.1 Image Rectification

Manually extract a set of corresponding points (a minimum of 8) between the two images. Use these correspondences to estimate the fundamental matrix F. See page 21-6 of the Lecture 21 scroll or page 282 of the text for the 8-point algorithm for estimating F from these correspondences. (The comment on page 21-6 regarding your needing 40 correspondences does not apply to manually selected correspondences.) After the linear least-squares estimation of F , you must also refine F by nonlinear optimization as described on pages 22-1 and 22-2 of Lecture 22 scroll. And, yes, do not forget to enforce the rank constraint on the fundamental matrix. Rectify the images using the estimated fundamental matrix.

2.2 Interest point detection

Your next goal is to construct automatically a large set of correspondences between the two images. Toward that end:

- Use SIFT or SURF or Harris Corner Detector to extract interest points in the two images and for establishing correspondences between the points thus chosen.
- For extra credit, you could also try using the Canny edge detector for this.

- If your image rectification is "perfect", given a pixel in the first image, all you'd need to do for finding the corresponding pixel in the second image is to look at the same row in the latter. Ordinarily, you'd look in the same row and in a small number of adjoining rows for the correspondences. If your rectification procedure is not working at all, directly use the epipolar constraint to establish correspondences between the extracted interest points between the two images.
- In most cases, for any given pixel in the first image, you will end up with multiple candidates in the second image. In such cases, use the SSD or the NCC metric to select the best candidate for each pair of correspondences.
- You also need to ensure that the ordering of the interest points on an epipolar line (which would be a row if your rectification procedure is working well) in the second image is the same as that of the corresponding points in the second image.

2.3 Projective Reconstruction

- For triangulating from the correspondences, use the procedure described on pages 22-2 and 22-3 of Lecture 22 scroll or in Sections 10.3 and 12.2 of the text. In light of the fact that you'll be reconstructing your scene with uncalibrated camera, your reconstruction will assume a canonical configuration for the cameras.

2.4 3d Visual Inspection

- Make a 3d plot of the reconstructed points. Draw some 'pointer lines' between the corresponding pixels in the two images, on the one hand, and between those pixels and the reconstructed 3d points on the other. If for example, you are using MATLAB, you can draw these lines directly in the figure window.
- Remember to include a display of the projective distortion in a fashion similar to the one on page 267 of the text. You can refer to previous years' solutions for the above mentioned points [I].

3 Submission

Show results on both datasets. You can download the first dataset from [I].

1. Turn in a typed pdf of your report via Blackboard.
2. Your pdf must include the following : -
   - A good description how you implemented each of the tasks above, with relevant equations.
   - The manually selected points used to estimate the fundamental matrix as well as the matched correspondences between interest points.
   - The reconstructed results with some marker or guide lines to understand the scene structure.
   - Any improvements that you see by using the LM method.
   - Your source code.

References

[I] `http://web.ics.purdue.edu/~bcomandu/ECE661/home/`
[II] `http://users.ics.forth.gr/~lourakis/levmar/`