# ECE 661: Homework 8

November 20, 2012

Due: November 29, 2012 (Thursday) before class

## Problem:

The goal of this homework is to carry out a projective reconstruction of the scene structure from a pair of stereo images. A reconstruction of a scene is projective if it is related to the actual scene by some $4 \times 4$ homography. To the human eye, a projective reconstruction can look like a very distorted form of the reality. A projective reconstruction can be converted into an affine reconstruction or even a similarity reconstruction with additional information about the locations and the orientations of the cameras. However, the goal of your homework is only to create a projective reconstruction.

A projective reconstruction requires no prior information about the camera matrices, or information about the scene geometry. You first construct the Fundamental Matrix $F$ from the point correspondences between the two images. Subsequently, you deduce a canonical configuration for the two cameras from the Fundamental Matrix. Finally, you use a triangulation-based method to compute the 3D points for every corresponding pair of pixels extracted from the stereo images.

Your homework involves the following steps:

1. Record a pair of stereo images with your handheld camera. You must make sure that you have a sufficient amount of overlap with regard to the scene structure as captured by the two cameras.

2. Manually mark a set of corresponding points (at least 8 points) between these two images. Use these correspondences to estimate the Fundamental Matrix using the 8-point algorithm described on page 282 of the textbook (Algorithm 11.1). Make sure that you enforce the constraint on the rank of the estimated Fundamental Matrix.

3. Apply the SIFT or SURF to extract the correspondences between two images as done in Homework 4 and 5.

    - (Extra credits) Instead of using SIFT or SURF, apply the Canny edge detector to two images for extracting interest points. Assume that all edge pixels output by the Canny operator are the interest-points that you will use for stereo matching. For each interest-point thus found in the left image, choose its corresponding right-image

interest-point by enforcing the epipolar constraint. If there exist multiple candidates for matching, use the one that yields the largest value for normalized cross correlation. Also make sure that the ordering constraint is satisfied on each epipolar line. What that means is that the left-to-right order of the interest points on an epipolar line in the left image must be the same as the left-to-right order of the corresponding interest points in the right image.

4. Now construct a canonical configuration for the cameras and then compute a projective reconstruction of the scene structure (See Section 10.3 for projective reconstruction and Section 12.2 for computing the coordinates of the world 3D points by the linear triangulation methods).

5. Finally, demonstrate the result by visualizing the 3D reconstructed points. One simple way to do this is by using the Matlab function `plot3`. If you used the C/C++ for this homework, save the 3D coordinates of the reconstructed points into a text file. Then visualize the 3d points by Matlab's plot3 and adjust the viewpoint of your result for best visualization.

Your homework submission must show the eight points used to compute the Fundamental Matrix and the matched correspondences used for reconstructing the scene structure. For a superior visualization of the accuracy of your reconstruction, you must draw some "pointer lines" between the corresponding pixels in the two images, on the one hand, and those pixels and the reconstructed 3D points, on the other. You may draw these lines directly in the figure window in Matlab. Make sure that your result includes a display of the projective distortion along the same lines as shown on page 267 of the textbook.

## Submission of Your Work:

For your homework solution, please turn in a report in pdf format using the blackboard. The report should include

1. A brief outline of the reconstruction procedure including any relevant equations.

2. You should show the eight points that you pick up to compute the Fundamental Matrix.

3. The matched correspondences used for scene reconstruction

4. The reconstructed results with some "guide" lines to help understand the scene structure.

5. Your source code along with comments.

You are permitted to look at sample solutions from previous semesters. However, the work you turn in must be your own. Clearly identify the steps you have taken to solve the problem with your own words. Your grade depends on the completeness and clarity of your work as well as the results.