ECSE 683 – Topics in Computer Vision and Robotics
Assignment 2
October 28, 2016

Due: November 11, 2016 at 5:00 pm

In this assignment we will investigate stereo, beginning with determining image correspondences and proceeding to full 3D reconstruction.

Files UI-L.jpg and UI-R.jpg correspond to the left and right camera images of a stereo camera rig. The extrinsic parameters are unknown, and the intrinsic parameters (identical for both cameras) are as follows:

focal length	f	30 mm
pixel x-dimension	S_x	0.05 mm
pixel y-dimension	S_y	0.05 mm
optical center x-offset	O_x	253
optical center y-offset	O_y	189.5
image width	W	605
image height	H	379

Problem 1: Determining Image Correspondences

Prior to determining Epipolar geometry and surface reconstruction, we first need to develop an algorithm that can both match and rank corresponding points in the left and right camera images. The goal is to select a highly reliable subset that can be used to estimate the Fundamental Matrix, F, and determine Epipolar Geometry.

1. Implement the correlation-based method described in Section 7.2.2. of the Trucco and Verri text using the sum of squared differences, SSD, as the matching metric. How can you use this metric to infer a measure of reliability on your matches? Determine the set of the 20 most reliable matching pairs; we will use this later on to estimate F. Examine your results and comment on the quality of your correspondences.
2. Repeat Part 1, but this time using a feature-based approach based on the corner detector outlined in Section 4.3 of the text. You need to give some thought on what attributes of the corner feature can be used to match corresponding corners, as well as a reliability measure for your matches. Again, use this measure to determine your 20 most reliable matching pairs. Comment on the quality of your correspondences and note any similarities in the two results.

Problem 2: Estimating Epipolar Geometry

We now proceed to estimating epipolar geometry and rectifying the input images.

1. Determine which of your two sets from Problem 1 is most "reliable" – explain why. These will serve as the basis for estimating the Fundamental Matrix, F, using the 8-point algorithm.
2. Determine the position of the epipoles in pixel coordinates in the left and right images. For the best 5 matching pairs in your most reliable set, plot the epipolar lines in the corresponding image. That is, for the 5 points in the left image, plot the corresponding epipolar lines in the right image and vice-versa.
3. Use F and the intrinsic parameters to estimate the Essential Matrix E, and use this estimate to estimate the unknown extrinsic parameters R,T using the procedure outlined in the text. Recall that both R and T have sign ambiguities, so you are going to have to check which one of the 4 possible configurations is the correct one.
4. With R,T you have sufficient information to implement the Rectification Algorithm described in Section 7.3.7 of the text. Use this to warp the two stereo images into a fronto-parallel configuration where epipolar lines lie on adjacent scan lines. Show the corresponding images.

Problem 3: Reconstruction up to a Scale Factor

Putting everything together, we now attempt to reconstruct the 3D surface that is most consistent with the left and right image projections. Because we are now working with rectified images, finding correspondences is greatly simplified. Using either the correlation or corner-based method obtain a dense set of correspondences and use it to reconstruct the corresponding 3D surface. You can use the Matlab or Octave mesh plotting function to visualize the resulting surface.

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