EE6132: Advanced Topics in Signal Processing

Programming Assignment - 3 : Depth Estimation from a Stereo Pair

Due date: May 12th 2016, 11:55pm IST

Note:

1. Please use moodle dicussion threads for posting your doubts and also check it before mailing to TAs, if the same question has been asked.
   (a) Problem 1, Vishnu ee12d038@ee.iitm.ac.in
   (b) Problems 1/2, Vijay vijay.ap@ee.iitm.ac.in
2. Submit a single zip file in the moodle named as PA3_Rollno.zip containing the report and codes.
3. Read the problem fully to understand the whole procedure.
4. Late submissions will be evaluated for reduced marks and for each day after the deadline we will reduce the weightage by 10%.

In this assignment, we will study the problem of stereo imaging. The goal is to estimate the depth map of the scene, i.e. the distance of each point in the scene from the camera, given two images captured by two cameras placed slightly apart from each other (Imagine human eyes). We will restrict ourselves to an estimation of only a relative depth, not the actual distances. To this extent, we will estimate a disparity map given two images (left and right images) captured by a stereo camera set-up. The disparity value of a pixel in the left image is defined as the distance in pixels of the corresponding pixel in the right image. We assume that the left and right images are rectified such that there are only horizontal translational disparities between them.

Problem-1: [**10 marks**] For this problem, we will use a simple cost function, which is equal to the data cost D_c., where D_c is a measure of error between two patches in the two stereo images for a given disparity value. Your task is to edit the `simple_depth.m` file as described below.

(a) In `simple_depth.m`, write code to create the data cost matrix D_c, which is of size $M \times N \times k$, where $M \times N$ is the image dimension and k is the number of predefined discrete disparity levels. For a particular pixel-translation (disparity) value d, for every pixel coordinate (i, j) (i=row, j=column), $D_c(i, j, \mathcal{I}(d))$ is the squared-ℓ_2-norm error between the $P \times P$ patch around the pixel (i, j) in the first (left) image `map0.ppm` and the translated patch around $(i, j + d)$ in the second (right) image `map1.ppm`. The translation is purely horizontal (i.e. column-wise).

(b) Estimate the disparity map dm, for every pixel coordinate as

$$dm(i, j) = \arg\min D_c(i, j, :),$$

and display the same as a depth map image (the code to display as an image is given).

(c) Vary patch size ($P = 1, 3, 5, 11, 21$) and compute ℓ_2-error between estimated depth map and ground truth depth map. Use `map0.ppm-map1.ppm` stereo pair, and `disp0.pgm` as the ground-truth depth map. Plot depth maps for different patch sizes.

(d) Now instead of using squared-ℓ_2 error for obtaining D_c, use ℓ_1 error (between the patch around the pixel (i, j) in the first image and the translated patch around $(i, j + d)$) and repeat the above.

(e) Now write code for obtaining the depth map for the pair of images, `tsukuba0.ppm` and `tsukuba1.ppm` and save it as a seperate file `simple_depth2.m`. Obtain plots for different patch sizes.

Problem-2: [**10 marks**] In this problem, we will use the graph cut method to estimate the depth map of a scene given two stereo images.

The cost to be minimized is

$$C = D_c + pS_c, \tag{1}$$

where D_c is the data cost, S_c is the smoothness cost, and p is the regularization parameter. The data cost is the error between two patches in the two stereo images for a given depth. The smoothness cost denotes the affinity of different depths at adjacent pixel locations. Use the data cost code written in Problem-1. We will use the Potts model as the smoothness cost (the code is given) and we will use the patch size to be 5×5 in this problem.

You are given the `GraphCut` package with compiled mex files. Please use `compile_gc.m` if the given compiled files are not working in your system. Your task is to edit the `gc_depth.m` file for questions (a) and (b), and the `gc_depth2.m` file for questions (c).

(a) In `gc_depth2.m`, find an appropriate p of the smoothness cost when squared-ℓ_2-norm error is employed for the calculation of D_c for which the estimated depth map is as close to the given ground truth depth map in terms of ℓ_2-distance. Use `map0.ppm-map1.ppm` stereo pair, and `disp0.pgm` as the ground-truth depth map. Find the best p amongst [1e-6,1e-5,1e-4,1e-3,1e-2,0.1,0.5,1,2,10].

(b) Repeat (a) when ℓ_1 error is employed for D_c calculation. Compare the performance on using ℓ_2 and ℓ_1 costs.

(c) Estimate the depth maps for the pair of images, `tsukuba0.ppm` and `tsukuba1.ppm`, using appropriate p values for ℓ_1 and ℓ_2 costs. Complete the code in `gc_depth2.m`.

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