Computer Vision I

Homework 4

Given November 3, 2017, Due: November 10 , 2017

Homographies and Stereo

1. (Old exam problem) The planar facade of a building is captured in an image taken by a camera. Assume this pane corresponds to the world coordinate frame's $Z = 0$ plane, and scene point (X, Y) on the building projects to image pixel coordinates (u, v).
   (a) What is the planar projective transformation that describes the relationship between (X, Y) and (u, v)? Give your answer using homogeneous coordinates.
   (b) How many degrees of freedom does this transformation have?
   (c) How many point correspondences are required to determine this transformation?
   (d) Would having more correspondences that your answer above be helpful in any way? If no, briefly explain why not. If yes, explain how they could be used.
   (e) Give one invariant of a planar projective transformation.
   (f) Give one invariant of a planar affine transformation that is not an invariant for a planar projective transformation.
   (g) If the building has sets of lines on it running parallel to both the X and Y axes, how could we use the corresponding lines in the image to determine if the building plane is parallel to the image plane?

2. Estimate the accuracy of the simple stereo system we discussed in class (identical cameras, translated from each other with coplanar image planes), assuming that the only source of noise is the localization of corresponding points in the two images. Hint: Take the partial derivatives of Z with respect to x, T, and f. Discuss the dependence of the error in depth estimation as a function of the baseline width and the focal length.

3. A template g is matched against an image f, both shown below:

f =

0	0	0	0	0	0	0	0
0	2	4	2	0	0	0	0
0	2	0	0	0	0	0	0
0	0	2	0	0	0	2	0
0	0	0	0	0	0	2	0
1	2	1	0	0	2	4	2
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0

g=

1	2	1
0	1	0
0	1	0

   (a) Find the SSD between f and g .

(b) Find the Correlation between f and g .

(c) Find the Normalized Correlation between f and g

4. (Old exam problem) Consider a room $10 \times 4 \times 4$ with world coordinate system (X, Y, Z) as shown in Figure 1. The room has a stereo rig with two identical cameras with focal length $f = 1$. Camera 1 is mounted on a wall such that its center of projection is located at the point $C1$ with **world coordinates** $(10, 1, 3)$. Camera 2 is mounted on a tripod and it has its center of projection located at the point $C2$ with **world coordinates** $(7, 1, 2)$. The optical axes of both cameras are parallel to the floor of the room, the image axes X_1 and X_2 are parallel to the world axis Y and the image axes Y_1 and Y_2 are parallel to the world axis Z as shown in Figure 1. The image plane of each camera is located at $Z_i = 1$, $i = 1, 2$.

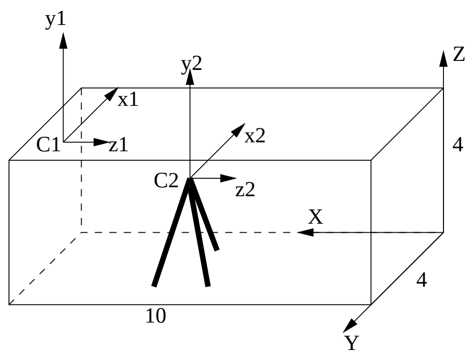

Figure 1: Room with a stereo rig.

(a) Find the transformation from the World to the Camera 1 coordinate system.

(b) Find the transformation from the World to the Camera 2 coordinate system.

(c) A feature matching algorithm run on an stereo pair from the two cameras has found that a point p_1 in the image from Camera 1 and a point p_2 in the image from Camera 2 are images of the same 3D point P. The point p_1 has **Camera 1 coordinates** $(-3/10, 1/10, 1)$ and the point p_2 has **Camera 2 coordinates** $(-3/7, 2/7, 1)$. Find the **world coordinates** of the 3D point P with images p_1 and p_2.