Capturing reality: Assignment sheet 2

November 17, 2011

In this assignment sheet, the problems 1-2 will be graded for a total of 20 points. A score of at least 10 points is required to register for the final exam.

Problem 1: Camera Models

For a full perspective camera,

1) How many degrees of freedom does its projection matrix P have? Please list all the freedoms and explain the meaning of each freedom.

2) Outline an algorithm to determine the projection matrix P from point correspondences $\{x_i \leftrightarrow X_i\}$ between points X_i in 3D space and points x_i on the 2D image. How many points are required?

3) Given the projection matrix P, is it possible to directly estimate the intrinsic matrix K from it? If yes, how to estimate? If no, please explain.

4) Imagine a square on a world plane that is imaged by a full perspective camera. How will it be distorted in the image ? What is the transformation that relates this world plane to the image plane ? How many degrees of freedom does this transformation have ? How many squares do you need to detect in order to estimate this transformation (assuming that the length of the side of the square in the world plane is known) ? Explain.

Problem 2: Epipolar Geometry and Fundamental Matrix

In one defined world coordinate system, there are a pair of cameras: camera A and camera B. The intrinsic matrix for camera A is K_1, and its rotation matrix and the position of its camera center are R_1 and t_1 respectively. For camera B, the intrinsic matrix, the rotation matrix and the position of the camera center are K_2, R_2, t_2 respectively.

1) Please give the projection matrix for camera A and B in terms of the parameters provided.
2) Please derive the fundamental matrix between camera A and B in terms of the parameters provided.
3) For one point p_a on the 2D image of camera A, please derive the epipolar line equation on the 2D image of camera B in terms of the parameters provided.
4) **Experiments on real data :** The attached zip file contains the calibration parameters provided and one pair of images captured by camera A and B. Specifically, the file “calib.txt” contains $K_1, R_1, t_1, K_2, R_2, t_2$. The image “img0.bmp” is captured by camera A, and the image “img1.bmp” is captured by camera B. Please write a MATLAB function which lets the user to select a point on one image and draws the corresponding epipolar line on the other image. For example, let user input the pixel position on one image, then display that image with the selected pixel marked in another color, and then display the other image with the corresponding epipolar line drawn in another color.