The Austalian National University Semester 1, 2024
School of Computing Tutorial 6
Dylan Campbell

COMP/ENGN 4528/6528: Computer Vision

Question 1 3D SFM and Image formation

1. (a) Given two calibrated cameras, C_1 and C_2, C_1 has a focal length of 500 in x and 375 in y, (in pixel unit) the camera has resolution 512×512, and the camera centre projected to the image is at $(249, 249)$, with no skew. Suppose C_2 has the same image resolution and focal length as C_1, but the camera centre projected to the image is at $(251, 252)$. Write down the calibration matrix K_1 and K_2 for C_1 and C_2 respectively.

   (b) Suppose that a 3D world coordinate system ((X, Y, Z) coordinates as in Figure 1) is defined as aligned with the camera coordinate system of C_1. More specifically, the world origin is at the camera centre of C_1, the Z axis is aligned with the optical (principal) axis and the X and Y world coordinate systems are aligned parallel with the x and y axes of the image of C_1. Write down the matrices $K[R|t]$ which define the projection of a point in the world coordinate system to the image of C_1.

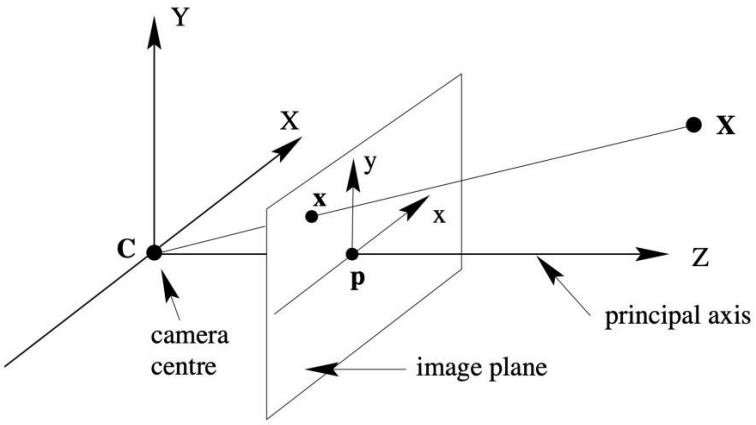

Figure 1: 3D coordinate systems

   (c) Suppose that the scene has a point, P_1, that in the world coordinate system defined above that lies at $(39, 35, 100)$. Note that the points in the world coordinate system are measured in centimetres. What location (to the nearest pixel) will that world point (P_1) map to in the image of C_1?

   (d) Suppose that with respect to the world coordinate system that is aligned with camera C_1, camera C_2 begins being aligned to C_1 and is then rotated by 45° about its vertical axis (Y axis) (as shown in Figure 2), and subsequently, the centre of C_2 is translated by 0.2 metre to the left of C_1 (along the X axis of C_1), then moved forward by 0.2 metre parallel to the optical axis of C_1. Write down the matrices $K[R|t]$, which define the projection of points in the world system (i.e, the same coordinate system of C_1) to the image of C_2.

   (e) Define the term "epipole".

   (f) For camera C_1, there is an epipole (or epipolar point) that relates to camera C_2. For the two-camera setup for predicting structure from motion, what is the position of the epipole in camera C_1 of camera C_2? (Hint: It is a point in the image coordinates of Camera C1).

Question 2 Epipolar geometry

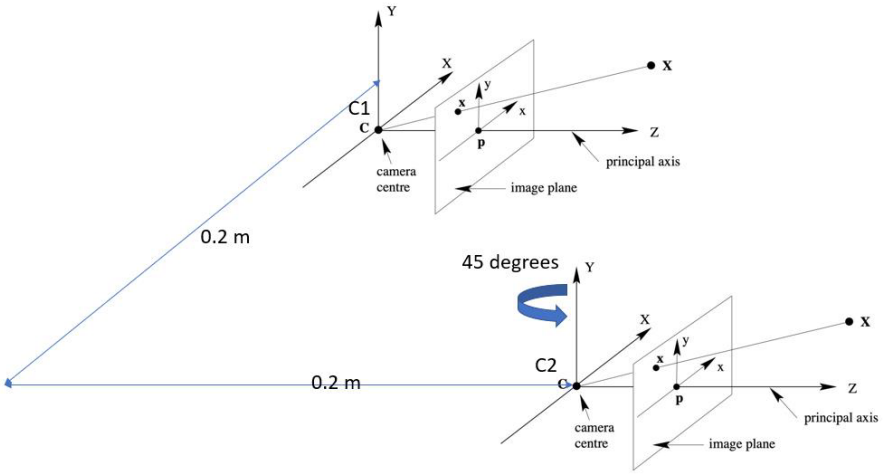

Figure 2: Visualisation of camera relative positions

1. Describe an algorithm to recover a fundamental matrix between two cameras given a set of 50 putative matching points between the cameras (that may contain errors).

Question 3 **Camera Calibration**

1. Complete the coding questions in `COMP4528_lab6_code.ipynb`.