Fundamental 3D Computer Vision
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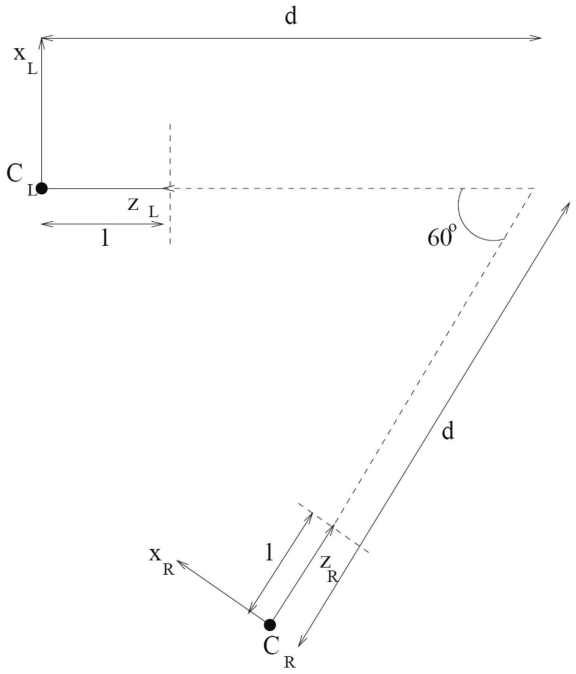
HW4 **Deadline**: 1402/09/24 **Support mail**: vida.rmz@gmail.com

1. Figure 1 shows a pair of cameras, each with a focal length of unity, whose principal axes meet at a point. The y-axes of both cameras are parallel and point out of the page. Assume that the left camera (center C_L) lies at the origin of the world coordinate system. Please answer the following questions about the figure.

a. Write down the camera matrices for this configuration and verify that the fundamental matrix F is:

$$\begin{pmatrix} 0 & -d/2 & 0 \\ -d/2 & 0 & -\sqrt{3}d/2 \\ 0 & \sqrt{3}d/2 & 0 \end{pmatrix}$$

b. Compute the epipolar line in the right image corresponding to the homogeneous point $x = (1, 1, 1)^T$ in the left, using $l = Fx$.



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2. a) Consider two identical cameras (such that K = K′) whose optical axis coincides with the z-axis, whose focal length is 0.03 m, with square pixels, no pinhole point offset, and zero skew. What is the expression of K?

b) Consider the point X^{in} expressed with respect to the first camera coordinate system. Suppose that $X^{in\prime} = RX^{in} + t$, where:

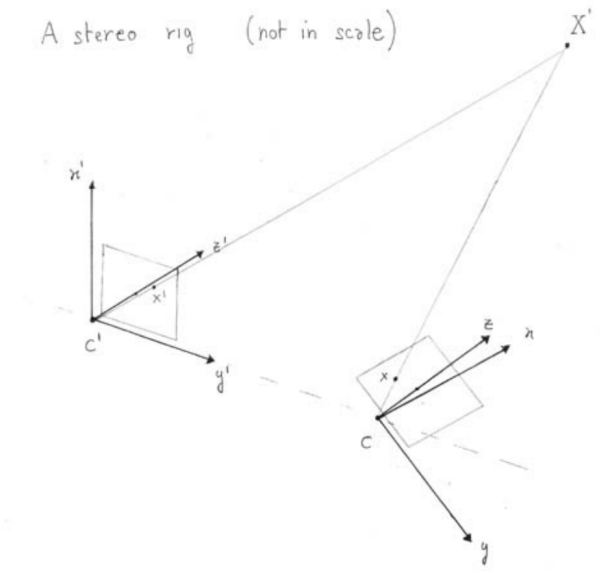
$$R = \begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & 0 \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \mathbf{t} = \begin{bmatrix} 0 \\ 0.2 \\ 0 \end{bmatrix}$$

Explain in words and with the help of the sketch in Figure 2 the spatial configuration of the stereo rig formed by the two cameras. In particular, explain the position of the second camera with respect to the first one.

c) Compute the fundamental matrix F associated with the stereo rig defined in parts a and b.

d) Consider the point with coordinates $X = [0.1 \ -0.1 \ 0.8 \ 1]^T$. What are the coordinates of the projection of X on the image plane of the first camera?

e) What is the epipolar l′ line corresponding to x calculated in part d?



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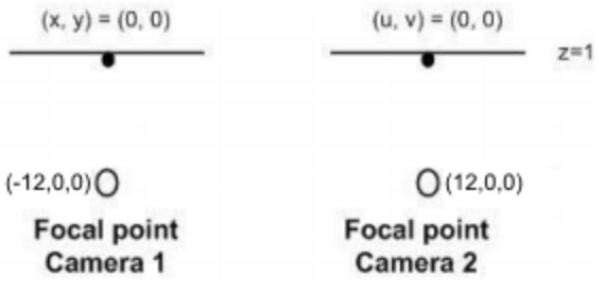
3. Consider two cameras whose image planes are the z = 1 plane and whose focal points are at (−12, 0, 0) and (12, 0, 0). We'll call a point in the first camera (x, y) and a point in the second camera (u, v). Points in each camera are relative to the camera center. So, for example, if (x, y) = (0, 0), this is really the point (−12, 0, 1) in world coordinates, while if (u, v) = (0, 0), this is the point (12, 0, 1).
Suppose the point (x, y) = (8, 7) is matched with a disparity of 6 to the point (u, v) = (2, 7). What is the 3D location of this point?



Implementation Section

4. Fundamental matrix estimation:
Using using Python packages, adjust and complete the provided notebook.
Implement the two missing functions:

a. Implement the eight-point algorithm. (`estimateF(x1,x2)`)
b. Implement the normalized eight-point algorithm. (`estimateFnorm(x1,x2)`)
The epipolar lines obtained with both F-matrix estimates(a,b) should be close to those visualized by the example script (`vgg_F_from_P (x1,x2)`).