Image Signal Processing

Tutorial – 1: (Pinhole Camera)

Q 1. For the given intrinsic camera matrix, determine the explicit values of the parameters defining the internals of a camera: focal length, the principal point, skew, and scaling in the x, y-directions. The intrinsic matrix for the camera is

$$\mathbf{K} = \begin{bmatrix} 10 & 0 & 10 \\ 0 & 10 & 10 \\ 0 & 0 & 1 \end{bmatrix}$$

Q 2. An ideal pinhole camera has focal length 5 mm. Each pixel is 0.02 mm×0.02 mm and the image principal point is at pixel $(500, 500)$. Pixel coordinates start at $(0, 0)$ in the upper-left corner of the image. What is the 3×3 camera calibration matrix, $\mathbf{K}$, for this camera conguration?

Q 3. A scene point at coordinates (400,600,1200) is perspectively projected into an image at coordinates (24,36), where both the coordinates are given in millimeters in the camera coordinate frame and the camera's principal point is at coordinates (0,0,f) (i.e., $u_0 = 0$ and $v_0 = 0$). Assuming the aspect ratio of the pixels in the camera to be 1, what is the focal length of the camera? (Note: the aspect ratio is defined as the ratio between the width and the height of a pixel.)

Q 4. The circle $x^2 + y^2 = 4$ is warped by the affine transform $A = \begin{bmatrix} 1 & 0.2 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$. What is the equation and shape of the curve obtained after warping?

Q 5. Let $u = [u_1, u_2, 1]^T$ and $v = [v_1, v_2, 1]^T$ denote the homogeneous coordinates of points in planes P and Q, respectively. Matching point pairs are related by a projection matrix H as:

$$v_i = Hu_i, \quad i = 1, 2, ..., n \tag{1}$$

A transform from P to Q in the form of a translation by (x_0, x_1) then a rotation by θ and then a scaling by (s_0, s_1) is described by the matrix:

$$H = \begin{bmatrix} 0.95162 & 0.443749 & -6.97686 \\ -0.40148 & 0.860992 & -2.29753 \\ 0 & 0 & 1 \end{bmatrix} \tag{2}$$

Determine the values of $(x_0, x_1, s_0, s_1, \theta)$.

Q 6. State true/false:

1. Rotation by 30° about X axis followed by 60° about Z axis is same as rotating by 60° about Z axis followed by rotation by 30° about X axis.

2. Parallel lines in an image will remain parallel after applying a homography.

3. Rotation, Affine and Projective transforms in Euclidean space can be expressed simply as a linear map in homogeneous coordinates.

4. RANSAC is used to get rid of outliers in situations when there are not enough point correspondences for least-squares estimation to work well.