CS172 Computer Vision I

Quiz 3

Closed book quiz!   Answer in English!

Name (in Chinese):

Student ID:

Question 1: Fitting

RANSAC algorithm is an iterative method based on random sampling for solving model fitting problems with noisy and outlier data sets. Assume that the initial outlier ratio e is set to 50% (e = 0.5), and the desired probability of success p is 0.99. The model requires s = 2 points per sample.

(1) Derive the formula for number of samples $\boldsymbol{N}$ in terms of the outlier ratio $\boldsymbol{e}$ and the number of points per sample $\boldsymbol{s}$.

(2) During the first iteration, 70% of the points are determined to be inliers. Recompute the outlier ratio e and the updated number of samples N.

Question 2: Hough Transform

Hough transform is a widely used technique in the field of computer vision and image processing, which can transform any curve or shape into a set of points in parameter space.

(1) Where is the line that contains both rectangular coordinates (x_0, y_0) and (x_1, y_1) map to the Hough space? Please draw it.

(2) When it comes to polar representation, e.g. $p_0 = x_0 \cos\theta + y_0 \sin\theta$, what is the pattern in the (θ, p) parameter space? Please draw it.

Question 3: Projection and Vanishing point

The camera shown in the figure has its x, y and z axes aligned with the world's y, z and x axes respectively. The world frame's origin is at (0, -h, 4h) in the camera' frame.

(1) By deriving a succession of Euclidean transformations, find the camera's extrinsic camera calibration matrix [R | t], such that

$$X_c = \begin{bmatrix} R & t \\ 0 & 1 \end{bmatrix} X_w$$

(2) The "Ideal" image plane is placed at $z_c = 1$. (Ideal means K is a 3 x 3 identity matrix.) Derive the image coordinates of the vanishing point of the family of lines parallel to the following line, expressed parametrically as:

$$(X_w, Y_w, Z_w) = (2 + 4t, 3 + 2t, 4 + 3t)$$

(3) The actual camera has $\mathrm{f_x} = 800, \mathrm{f_y} = 750, \mathrm{s} = 0, (\mathrm{u_0}, \mathrm{v_0}) = (\mathrm{cx}, \mathrm{cy}) = (350{,}250)$. Derive the coordinates in the actual image plane of the vanishing point of (2).

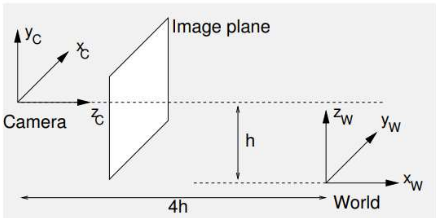

Figure 1

Question 4: Stereo

Two cameras are looking at a scene. They have projection matrices $P^{(1)} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}$ $and\ P^{(2)} = \begin{pmatrix} 0.8 & 0 & 0.4 & -2 \\ 0 & 1 & 0 & 0 \\ -0.4 & 0 & 0.8 & 4 \end{pmatrix}$. A 3D world point appears in the first image at the location (2, 0), and in the second image at location (-18, 0). What is the 3D location of this world point?