Indian Institute of Space Science and Technology Trivandrum

I SEMESTER , **2022**

ExamType: Quiz 1

DEPARTMENT OF AVIONICS

computer vision/ computer vision and advanced image processing

(Time allowed: ONE hours)

NOTE: Read all questions first. **There are questions worth 30 marks.** If something is missing in a problem description, clearly mention your assumptions with your solution. If require, use sketches to illustrate your findings.

1. Explain what are the key ideas that are used in edge detection. What all things can cause an edge in an image. Name a few methods to detect edges in the image. How Sobel edge detection method works. (5 marks)

2. The image below is an image of a 3 pixel thick vertical line. (5 marks)

(a) Show the resulting image obtained after convolution of the original with the following approximation of the derivative filter $[-1; 0; 1]$ in the horizontal direction. How many local maxima of the filter response do you obtain ?

$$\begin{bmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \end{bmatrix}$$

(b) Suggest a filter which when convolved with the same image would yield a single maximum in the middle of the line. Demonstrate the result of the convolution on the original image.

(c) What is a difference between Gaussian smoothing and median filtering? How would you decide to use one vs. another ?

3. Given two lines in the image denoted by their projective coordinates l_1 and l_2, how would you compute an intersection point of these two lines ? (1 mark)

4. Show that the line through two 2D points x and x' is $l = x \times x'$. (1 mark)

5. Under homography, how can we write the transformation of points in 3D from camera 1 to camera 2? Explain (mention all the steps needed) how do we estimate the homography. (3 marks)

6. What does it mean for the 2D convolution kernel (filter) to be separable ? (1 mark)

7. Which of the following statements are true of a pinhole camera? Which are false? (1 mark)

(a) (A) Images in a pinhole camera are upside down.
(b) (B) A pinhole camera has a fixed focal length,f.
(c) (C) Images in a pinhole camera are a perspective projection

8. (write all that apply) Which of the following could affect the intrinsic parameters of a camera? (1 mark)

(a) A crooked lens system.
(b) Diamond/Rhombus shaped pixels with non right angles.
(c) The aperture configuration and construction.
(d) Any offset of the image sensor from the lenss optical center.

9. state true or false (with a proper reasoning)

(a) Pincushion distortion modifies the image only along the vertical direction and barrel distortion modifies the image only along the horizontal direction. (1 mark)
(b) The vanishing point associated with a line in 3D space (when viewed through a pinhole camera) can never be a point at infinity (1 mark)
(c) The result of applying a scale, rotation, and translation (in that order) to a vector $\mathbf{v}$ is equal to the result of applying the same rotation, translation, and scale (in that order) to the same vector $\mathbf{v}$. (1 mark)
(d) It is impossible to estimate the intrinsic parameters of the camera given a single image even with prior information about the scene (1 mark)

10. Which of the following always hold(s) under affine transformations? (1 mark)

(a) Parallel lines remain parallel
(b) Ratio of lengths of parallel line segments remain the same
(c) Ratio of areas remain the same
(d) Perpendicular lines remain perpendicular
(e) Angles between two line segments remain the same

11. The figure (1) below shows the outputs of applying one of transformations (projective, affine, similarity, and isometric) to a square with vertices at (1,1), (1,-1), (-1,-1), (-1,1) tell which is the most specific transformation used to generate each output. if possible write the transformation matrix and write the degrees of freedom. (2 marks)

12. Suppose we want to solve for the camera matrix K and that we know that the world coordinate system is the same as the camera coordinate system. Assume the matrix K has the structure outlined below. Note that K_{33} is an unknown. Assume that we are given n correspondences.

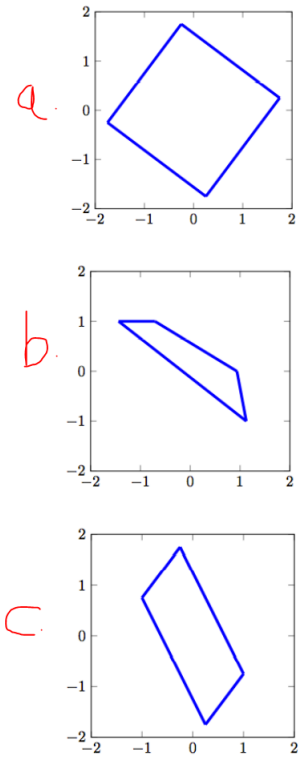

Figure 1: figure for understanding the various transfrom (a) (b) and (c) top-to-bottom respectively)

Each correspondence consists of a world point (x_i, y_i, z_i) and its projection (u_i, v_i) for $i = 1, ..., n$. (5 marks)

$$\begin{pmatrix} K_{11} & K_{12} & K_{13} \\ 0 & K_{22} & K_{23} \\ 0 & 0 & K_{33} \end{pmatrix}$$

(a) What is the minimum number of correspondences needed to solve for the unknowns in the matrix K?

(b) Set up an equation of the form $Ax = 0$ to solve for the unknowns in K (where A is a matrix, and x and 0 are vectors). Be specific about what the matrix A and vector x are.

(c) Explain how to solve for the unknowns in the camera matrix K. Make sure $K33 = 1$.