Indian Institute of Space Science and Technology Trivandrum

II SEMESTER , **2025**

ExamType: End Sem(Summer Supp.)

DEPARTMENT OF AVIONICS

computer vision/ computer vision and advanced image processing

(Time allowed: TWO hours)

NOTE: Read all questions first. There are total questions worth 55 marks. **You can attempt any questions worth 50 marks.**

1. Under what conditions will a line viewed with a pinhole camera have its vanishing point at infinity? (2 Marks)

2. Explain Affine transform. write necessary equations to explain that. how many DoF are there in Affine transform. (2 Marks)

3. Explain working principles of Mean-shift algorithm. How this algorithm can be used for image segmentaion. (4 Marks)

4. How does the Harris feature detector works. What is the use of Harris corner detection method. Derive the auto-correlation matrix (i.e., give the proof). What are the properties of the auto-correlation matrix? How is it useful for detecting interest points?(4 Marks)

5. In many applications, an image is smoothed by applying Gaussian filters of several sizes. Why would one want to smooth an image using different parameters of the Gaussian?(2 Marks)

6. Why is a Gaussian filter preferred to a box filter?(2 Marks)

7. What do you do to sharpen an image?(2 Marks)

8. Explain RANSAC method and List the main 3-5 steps of RANSAC as applied to line fitting with outliers.(3 Marks)

9. What is the aperture problem?(2 Marks)

10. What is the direction in the image along which optical flow cannot be reliably estimated and why?(3 Marks)

11. Let $(X_i \in R^3)_{i=1}^N$ be a set of points in R^3 that are transformed by a 3D affine transformation (A,T), where $A \in R^{3\times3}$ and $T \in R^3$, to produce another set of points $(Y_i \in R^3)_{i=1}^N$. Suppose that the transformed points Y_i are corrupted by noise E_i, i.e. $Y_i = AX_i + T + E_i$ for all $i = 1, , N$.

Show that the transformation (A,T) that minimizes the sum of squared errors.

$$E(A,T) = \sum_{i=1}^{N} ||Y_i - AX_i - T||_2^2$$

is given by $T^* = \tilde{Y} - A*\bar{X}$, $A^* = (YX^T)(XX^T)^{-1}$, where $\bar{X} = \sum X_i/N$ $X = (X_1 - \bar{X}, , X_N - \bar{X})$. and similarly for $\bar{Y}$ and Y. Show that 4 is the minimum number of points needed to find the transformation.(5 Marks)

12. Loss function is a measure to compute the error over the entire dataset: (True or False)(1 Marks)

13. which statements are true about about intrinsic and extrinsic parameter matrices.(1 Marks)

(a) Intrinsic parameter matrix converts image coordinates in to pixels.
(b) Extrinsic parameter matrix converts world coordinate into camera coordinates. The diagonal elements in the extrinsic parameter matrix account for different scaling in x and y direction of a pixel.
(c) all are true

14. which statement(s) is (are) true about the Hough transform?(1 Marks)

(a) when detecting ellipses it is necessary to define an R-table
(b) when detecting a circle with a known radius, a 2D accumulator array is used
(c) it can detect partially visible circles
(d) it can only detect lines and circles.

15. If we initialize the k-means clustering algorithm with the same number of clusters but different starting positions for the centers, the algorithm will always converge to the same solution. Why or why not?(2 Marks)

16. What is Object Detection. Explain how PCA can be used for object detection. (5 Marks)

17. The fundamental matrix is not invertible. (True or False) (1 Marks)

18. What is the difference between convolution and correlation? Under what condition is convolution equivalent to correlation? (2 Marks)

19. Derive Lucas and Kanades optical flow equations from the first principle. What is the main difference between (Horn and Schunck) and (Lucas and Kanades). When Lucas and Kanade method will fail. (5 Marks)

20. Explain the details of k-Means clustering. Apply K-mean clustering on the given data and find the two cluster centers and which all points will belong to which cluster center after one iteration. Show your work. (5 Marks)

$Height$	185	170	168	179	182	188	180	180	183	180	180	177
$Weight$	72	56	60	68	72	77	71	70	84	88	67	76