Indian Institute of Space Science and Technology Trivandrum

I SEMESTER , 2025
ExamType: Quiz 1

DEPARTMENT OF AVIONICS
computer vision and Deep learning/ 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 Canny edge detection. (2 marks)

2. Recursive filtering techniques are often used to reduce the computational complexity of a repeated operation such as filtering. If an image filter is applied to each location in an image, a (horizontally) recursive formulation of the filtering operation expresses the result at location (x + 1, y) in terms of the previously computed result at location (x, y). (4 marks)

   A box convolution filter, B, which has coefficients equal to one inside a rectangular window, and zero elsewhere is given by:

$$B(x, y, w, h) = \sum_{i=0}^{w-1} \sum_{j=0}^{h-1} I(x + i, y + j)$$

   where I(x, y) is the pixel intensity of image I at (x, y). We can speed up the computation of arbitrary sized box filters using recursion as described above. In this problem, you will derive the procedure to do this.

   (a) The function J at location (x,y) is defined to be the sum of the pixel values above and to the left of (x,y), inclusive

$$J(x, y) = \sum_{i=0}^{x} \sum_{j=0}^{y} I(i, j)$$

   Formulate a recursion to compute J(x,y). Assume that $I(x, y) = 0$ if $x < 0$ or $y < 0$. Hint: It may be useful to consider an intermediate image to simplify the recursion.

   (b) Given J(x,y) computed from an input image, the value of an arbitrary sized box filter (BJ) applied anywhere on the original image can be computed using four references to J(x,y).

$$BJ(x, y, w, h) = aJ(?, ?) + bJ(?, ?) + cJ(?, ?) + dJ(?, ?)$$

   Find the values of a, b, c, d and the ?s to make this formula correct. Specifically, your answer should be the above equation with appropriate values for the above unknowns. Hint: It may be useful to visualize this process as shown in Fig. below.
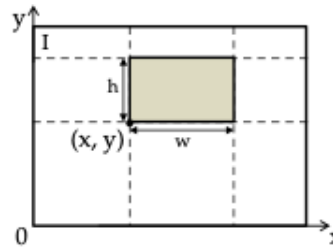
Figure 1: figure for understanding the integral image idea

3. convince your self and show intuitively that when a two dimensional filter is separable then it requires less number of computations. Write the kernel for two-D Sobel filter. Show that whether it is separable or not. Moreover can we say that a Sobel filter is nothing but It is similar to applying a Gaussian filter followed by a derivative. Justify your reasoning. Is the following convolution kernel separable? If so, separate it. If not, prove that it is not.   (3 marks)

$$H = \begin{bmatrix} 2 & 3 \\ 2 & 1 \end{bmatrix}$$

4. Explain what is perspective projection? Under what conditions will a line viewed with a pinhole camera have its vanishing point at infinity? Justify. Write what all are the intrinsic and extrinsic parameters of the camera. What could affect the intrinsic parameters of a camera? Give proper reasoning. Show how one can use homogeneous coordinate system to express an arbitrary three dimensional world point P(X,Y,Z) in terms of image coordinate p(x,y). Show all the necessary steps that required to achieve that with proper justification.   (3 marks)

5. Explain whether Downsampling can lead to aliasing or not ? What is the reason for aliasing when we downsample an image? Which processes would help avoid aliasing while downsampling an image?   (2 marks)

6. A scene point at coordinates (400,600,1200) is perspectively projected into an image at coordinates (24,36), where both coordinates are given in millimeters in the camera coordinate frame and the cameras principal point is at coordinates (0,0,f) (i.e., u0 = 0 and v0 = 0). Assuming the aspect ratio of the pixels in the camera is 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.   (2 marks)

7. Explain the algorithm of Hough transform for detecting lines. Extend the Hough transform idea for detecting circles.   (2 marks)

8. Write what could be the best objective/loss function for classification and what could be the best objective/loss function for regression ? Explain it all the terms that you used in your expression intuitively.   (2 marks)