Computer Vision 22-23
Sheet 1

Linear Image Processing

Q1) For an image I(x, y), define its gradient vector field $\vec{\nabla}$I(x, y).

- Why is this vector field a useful thing to compute?
- Explain how the gradient vector field is used in the Canny edge detector, the main steps in its use, and its advantages.

Q2) An image of size 5x5 is given below. Find the following: **(a)** the output of a 3x3 averaging filter at (1,1), **(b)** the output of a 3x3 median filter at (1,1) and **(c)** the gradient magnitude at (1,1) using the Sobel masks shown below.

IMAGE

y \ x=	0	1	2	3	4
0	3	7	6	2	0
1	2	4	6	1	1
2	4	7	2	5	4
3	3	0	6	2	1
4	5	7	5	1	2

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Q3) Explain a solution to the following problems in images (giving an example of each):

- The image details such as edges are blurred and not clear.
- The image contrast is very poor.

Q4) What is the main difference between Correlation and Convolution? Considering the following Laplacian filter for edge detection, do you think that image correlation results will be different or equal to image convolution with that filter? Explain.

$$\begin{matrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{matrix}$$

Q5) Explain the effect of Variance σ in Gaussian filter of image noise removal.

Q6) In the process of edge detection from linear images; smoothing the image using Gaussian filter and then applying a gradient filter is mathematically identical to have the derivative of the Gaussian filter first and after that convolve the resulted filter with the image.

- **i)** Explain what helps the two operations to be mathematically identical.
- **ii)** Irrespective of the final results, which operation do you think is most preferable to use? Why?

Q7) Describe the steps of the Canny algorithm used for edge detection from linear images.

Features

Q1) In the **Harris** feature detector, describe what is the second-moment matrix? Explain its role and how this is used to select good features.

Q2) In computer vision, a feature is a piece of information which is relevant for solving the computational task related to a certain application. Features may be specific structures in the image such as points, edges or objects.

- **i.** What does it mean if an image feature is invariant to a transformation X? Give two examples of X.
- **ii.** Why is having invariance a good characteristic for an image feature detector?
- **iii.** What is the main difference between an image feature detector and feature descriptor? Name an example algorithm for each of them.
- **iv.** Explain how you can make your named feature descriptor rotationally invariant

Q3) What feature detector would you use to propose a set of probable correspondences between two images of the same object, but taken with a different rotation and zoom setting?
Explain only the step(s) of how this feature detector is set to be rotationally invariant?

Q4) Describe the Harris detector for corner detection of a 2D image by giving the main steps of the algorithm with description of the used parameters.