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CSL 783 Digital Image Processing
Major

Max Marks: 80 **Duration 2 Hrs**

1. (a) A binary image A is subjected to the opening operation and the result A' is obtained. What happens if another opening operation with the same structuring element is applied on A'?

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(b) You are required to obtain the Distance From Boundary (DFB) map for an object shown below in a binary image using Morphological operations. The DFB pertains to the distance (can consider city-block or D4 distance) of pixels inside of an object from its boundary. Give the required Morphological operations and corresponding structuring element to perform the computation of the DFB. Show the steps of computing DFB on the example below. Suggest an application of computing DFB.

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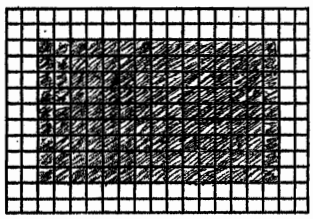

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2. (a) Why simple thresholding is not a good method for segmentation?

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(b) **Traffic Monitoring System**: You have been assigned the job of developing a simple traffic monitoring system. The system should be able to count and label the class of a vehicle in road traffic that may have passed over a period of time. Consider three classes: small, medium and large. Vehicles are viewed from (almost) orthographic camera and the decision parameters for the classes are the length and width of a vehicle. An average value for these parameters is known for each class of the vehicle and the parameters value for the various samples in each class may vary about $\pm 10\%$. Give your scheme with each stage of processing and techniques from what you have studied in CSL783 that you would use with a justification. The input is given in the form of a video sequence of a road traffic captured from a video camera that is placed in such a manner that it gives near orthographic view of the road. State your assumptions that may have been used in your scheme.

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3. Consider an image with **N** pixels. For the pyramid structure, what is the extra storage needed for the image. Given the Laplacian Pyramid with **M** levels, how would you reconstruct the image (assuming $L_M=G_M$, where G_M corresponds to the M^{th} level Gaussian approximation of the image and L_M corresponds to M^{th} level Laplacian approximation of the image) How can one achieve compression using Laplacian pyramid structure?

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4. (a) How image restoration is different from image enhancement?

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(b) For the constrained least square restoration someone suggests that one can obtain a useful filter by considering minimization of the negative of the entropy (or maximization of the entropy) subject to the constraint $\|g - Hf\|^2 = \|n\|^2$. The entropy of the image may be defined as $E = -f^T \ln f$, where f is the image expressed in a vector form and ln is natural log. Work out the solution of the constrained restoration image. Verify that the solution under a linear approximation becomes the standard constrained least square solution $(H^T H + \gamma Q)^{-1} H^T g$) with $Q=I$ (Identity).

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5. (a) What happens to the Fourier Transform when an image is rotated by an angle θ ?

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(b) Let us consider a situation where an affine transformation is applied to an image. Work out the Fourier transform of the image after the transformation in relation to the Fourier transform of the original image. Let $F(u,v)$ and $f(x,y)$ form 2-dimensional Fourier pair, and the point $\mathbf{x}$ (x, y) after the affine transformation become $\mathbf{x'}$ (x',y') as below.

$$\mathbf{x'} = \mathbf{Ax} + \mathbf{t}$$

where $\mathbf{A}$ is a 2x2 linear transformation matrix and $\mathbf{t}$ is the translation vector.

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6. A high pass filtered image can be obtained by subtracting a low pass filtered image from the original image. Show that this is true both in spatial and frequency domains. For spatial domain you may consider a mask of 3x3.

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7. Why are B type of frames used in MPEG? An MPEG sequence has the following sequence of frames, which have the order of display as written below. What is the order in which these frames are encoded and transmitted? Justify your answer.

I	P	B	B	P	P	B	P	I
1	2	3	4	5	6	7	8	9

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8. Give a short answer to the following questions.

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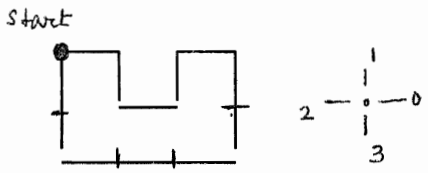
A) What is the entropy of the source that uses M equally probable symbols?

B) What will you use optical flow for?

C) Give the chain code and the shape no of the following figure.



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D) An image (I) is subjected to histogram equalization and produces the resulting image (I'). I' is again subjected to the histogram equalization and produces I''. In what way the histograms of the images I' and I'' are related?

E) Consider the Sobel operator for the horizontal direction. This Sobel operator can be constructed by convolving the following two masks:

F) Why JPEG uses DCT and not KLT (Hotelling Tranform)?

G) A 2D point in image can be obtained from a point in 3D world by applying $X_{image} = P X_{scene}$. P is the projection matrix. Can a point in 3D be obtained by $X_{scene} = P^{-1}X_{image}$?

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H) How would you state and formulate the problem of image super-resolution?

I) In assignment 2, if you are asked to do morphing using three images instead of two images how will you compute an intermediate image?

J) For your assignment 3 on wavelets, which wavelets did you use? Give in brief the implementation of the application you chose.