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INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: __-Sep-11 FN/AN **Time: 2 Hrs** **Full Marks: 60** **Deptt: Computer Sc. & Engg.**
No. of Students: 38 **Mid Autumn Semester Examination, 2011-12**
Subject No: CS40019 **Subject Name: Image Processing**
3rd / 4th Year B.Tech. (H) **Instruction: Attempt *any six* questions**

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1. [12*0.5+ 2*2]

a. Match the following applications of image processing techniques with the respective EM bands of imaging used in them. Just match the number with the letter. There is no need to provide additional information or explanation.

Image Processing Application	**EM Spectral Band**
1. Angiography	A. Gamma Rays
2. Automated Visual Inspection	B. X-Rays
3. Computed Axial Tomography (CAT)	C. Ultra-Violet
4. Finger Printing	D. Visible and Infrared
5. Fluorescence Microscopy	E. Microwaves
6. Magnetic Resonance Imaging (MRI)	F. Radio Waves
7. Optical Mark Recognition (OMR)	
8. Positron Emission Tomography (PET)	
9. Remote Sensing	
10. Silicon Photolithography	
11. Space-borne Radar	
12. Weather Prediction	

b. Outline the state-of-the-art image processing techniques for the following applications. Provide as much specific information as you can and explain the approach in brief.

Attempt any two.

i. Oil-Spill Monitoring in the Deep Sea
ii. Ice-Mapping of the Arctic
iii. Ball Tracking in a Tennis or Cricket Match
iv. Defect Detection in IC Fabrication

2. [2+ (4+4)]

a. Let V = {1, 2} and draw the shortest 4-, 8- and m-path between **p** and **q** and compute their lengths. Are the paths unique?

	3	1	2	1	**(q)**
	2	2	0	2	
	1	2	1	1	
(p)	1	0	1	2	

b. Chamfer Distance (Norm) for approximating Euclidean Distance e(P) is defined as: $d_{a,b}(P) = \max(|x|,|y|).a+\min(|x|,|y|).(b-a)$, where P = (x,y).
   i. Given local neighborhood weights, a and b, let $E_{max}(a,b)$ represent the maximum relative error of $d_{a,b}(P)$ with respect to e(P). Derive an expression for $E_{max}(a,b)$ in terms of a and b.
   ii. Using symmetric error criterion for minimization of $E_{max}(a,b)$, that is, $-E(0) = E(\pi/8) = -E(\pi/4)$; show that E minimizes for $b = \sqrt{2}a$ and $a = (1+\sin(3\pi/8))/2$.

3. Consider a simple 4 X 8, 8-bit image: [1+2+1+2+2+2]

21	21	21	95	169	243	243	243
21	21	21	95	169	243	243	243
21	21	21	95	169	243	243	243
21	21	21	95	169	243	243	243

a. Computer the entropy of the image.
b. Compress the image using Huffman coding.
c. Compute the compression achieved and the effectiveness of the Huffman coding.
d. Consider Huffman encoding pairs of pixels rather than individual pixels. What is the entropy of the image when looked at pairs of pixels?
e. Consider coding the differences between adjacent pixels (column-wise, keeping the first column intact). What is the entropy of the new difference image? What does this tell us about compressing the image?
f. Explain the entropy differences in (a), (d) and (e).

4. [(2+1)+3+4]

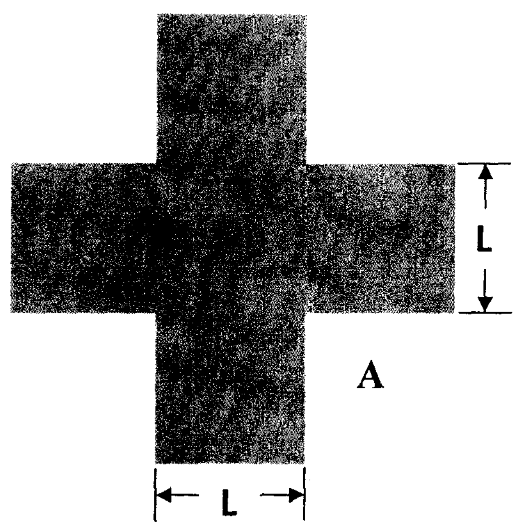
a. Create a general procedure for converting a Gray-coded number to its binary equivalent and use it to decode 0111010100111.
b. Given a four-symbol source {*a*, *b*, *c*, *d*} with source probabilities {0.1, 0.4, 0.3, 0.2}, arithmetically encode the sequence *bbadc*.
c. Use the LZW coding algorithm to encode the 7-bit ASCII string "*aaaaaaaaaaa*". Take the ASCII code of '*a*' as 97 and assume that the LZW dictionary is filled with 256 ASCII characters at the start.

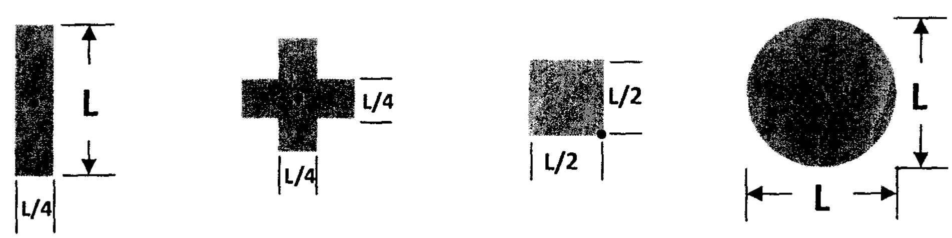
5. [(2+1+1)+(3+1)+2]

a. Outline JPEG coding of continuous tone black-and-white images. What is / are the primary source/s of compression in JPEG? What is the trade-off between fidelity and bit-rate?
b. Outline MPEG-1 coding for videos (use your explanation for JPEG as needed). What is / are the primary source/s of compression in MPEG-1?
c. What are the advantages of using B-frames for motion compensation?

6. Let A denote the set shown shaded in the following figure. Refer to the structuring elements B^{i}'s shown below (the black dots denote the origin). Sketch the result of the following morphological operations: [2+2+3+3]

a. $(A \ominus B^4) \oplus B^2$
b. $(A \ominus B^1) \oplus B^3$
c. $(A \oplus B^1) \oplus B^3$
d. $(A \oplus B^3) \ominus B^2$





B^1 B^2 B^3 B^4

7. [2+(1+1)+1+2+3]

a. State and briefly justify the conditions for image segmentation.

b. Using Taylor Series Expansion derive the expressions for discrete first and second partial derivatives for an image intensity function f(x,y). Design appropriate masks for computing discrete derivatives using the expressions.

c. Explain how a mask is customized to respond to a specific structure.

d. Consider the following pair of operators and characterize what do they compute:

Operator A

$$\begin{bmatrix} +3 & +10 & +3 \\ 0 & 0 & 0 \\ -3 & -10 & -3 \end{bmatrix}$$

Operator B

$$\begin{bmatrix} +3 & 0 & +3 \\ +10 & 0 & -10 \\ +3 & 0 & -3 \end{bmatrix}$$

$\rightarrow -3$

e. Outline an approach to detect various forms of edge discontinuities in gray-scale images.

8. Write short notes on *any two* of the following: [2*5]

a. Brightness discrimination by Weber Ratio

b. Bilinear Interpolation for image enlargement

c. Frequency domain techniques for digital image watermarking

d. Thinning a binary image by morphological operations