MILITARY COLLEGE OF SIGNALS
FINAL EXAM
BESE 13
EE 481 Digital Image Processing

Instructor: A/P Dr. Imran Siddiqi **Time: 2.5 Hours**
Max Marks: 50

Instructions

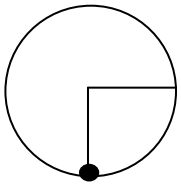
- Be concise in your answers and avoid unnecessary descriptions.
- Understanding the questions is a part of examination and do NOT request for your instructor to be called in the examination hall.
- This question paper comprises **4** pages.

(3+3+2)

1. **a.** An image *f(x,y)* is considered a function of two variables. In a similar manner, a video may be considered as a function of three variables *f(x,y,t)*. Suggest an expression to compute $\partial f / \partial t$ and state what it actually extracts from the video?

b. What is the double line effect of *Laplacian* filter and how can it be removed?

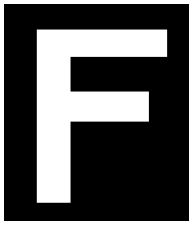
c. Consider the RGB color cube standing on the vertex (1,1,1). State the hue, saturation and intensity values of the color represented by the dot if the following is obtained by slicing the cube at 25% of its height.



(5+7.5+2)

2. **a.** Using hit-and-miss transform, propose an algorithm to detect end points in one pixel thin objects like the one shown in the following image. You need to mention the structuring element(s) and the steps the algorithm should perform. Be precise and to the point and do NOT provide descriptive details.

b. For the following image of character 'F', show the results of applying the listed morphological operators with 3x3 structuring element. (Assume that the size of structuring element is small with respect to the size of the object). Clearly indicate which parts of image are white and which are black.



i. $(A \oplus B) - A$

ii. $((A \oplus B) - (A \ominus B))^c$

iii. $(A^c \ominus B) \cap (A \oplus B)$

iv. $A \cap (A^c \oplus B)$

v. $(A \cup (A \circ B))^c$

c. Given A = {(1,1),(1,-1),(-1,-1),(-1,1),(0,0)}, B={(0,0),(0,-1),(0,1)} and z={(3,0)} find the $(A)_z$ and $\hat{B}$.

(4+4+6)

3. **a.** For the 5x5 gray scale image below, compute the coding redundancy if the variable length codes in the following table are used instead of 8-bit natural coding.

5	5	5	5	5
5	5	5	5	5
200	200	200	200	200
2	150	2	2	150
2	150	2	2	150

Image

Gray Level	Code
2	001
5	1
150	000
200	01

Variable Length Codes

b. Consider two successive frames *t* and *t+1* of a video. Frame *t* is an *I* frame while frame *t+1* is a *P* frame predicted from the *I* frame. Both frames are shown divided into macro-blocks and the starting coordinates of each macro-block are indicated on the top and left of each frame. Assuming the frame *t+1* is to be encoded, compute the motion vectors for each macro-block in frame *t+1*. The vectors are to be computed with reference to the starting point of each macro-block. For simplicity, only consider the macro-blocks containing the object.

	0	16	32	48
0				
16				
32				
48				

Frame t

	0	16	32	48
0				
16				
32				
48				

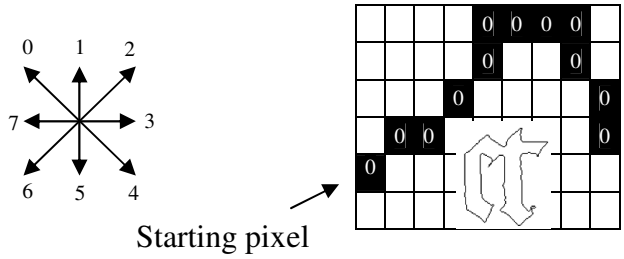
Frame t+1

c. You have received the number **0.2572167752** that has been encoded using Arithmetic coding. Given the probability and range of each character as indicated in the following table, decode the message.

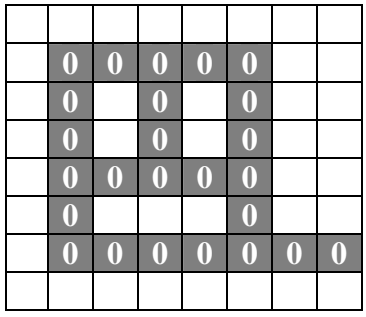
Character	**Probability**	**Range**
SPACE	0.1	[0.0 0.1)
A	0.1	[0.1 0.2)
B	0.1	[0.2 0.3)
E	0.1	[0.3 0.4)
G	0.1	[0.4 0.5)
I	0.1	[0.5 0.6)
L	0.2	[0.6 0.8)
S	0.1	[0.8 0.9)
T	0.1	[0.9 1.0)

(3+3+6+1.5)

4. **a.** Consider the small portion of the contour of a character in the figure below. Starting at the given position and using clock-wise traversal, compute the histogram of the differential chain code for the given segment of the character.



b. For the following object (represented by 0s), compute the horizontal and vertical '*Crossings*' vectors.



c. A system needs to inspect and divide a bunch of 10 pens into 3 different classes. The measurable attributes are the *length* and *diameter* of each pen and have the values as indicated in the following table:

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Length	3	8	4	1	6	7	2	5	3	7
Diameter	2	4	7	1	4	5	3	8	9	3

Taking P1, P3 and P6 as the initial cluster centers, run the first iteration of the *k-means* algorithm and show:

i. Clusters after first iteration – Which pens belong to which cluster
ii. Centers of clusters after first iteration
iii. How many more iterations are required for convergence?

Use the following definition of distance between P_i and P_j

$$D(P_i,P_j) = |(length)_i - (length)_j| + |(diameter)_i - (diameter)_j|$$

d. In the context of classification, what does the term '*good features*' refer to?

++++++++++++++ Bon Courage ++++++++++++