- CO1: Understand mathematical formulation of an image, its processing steps and relationship between image pixels.
- CO2: Apply Image enhancement using intensity transformations and spatial filtering.
- CO3: Analyze image enhancement for frequency domain using Fourier transform.
- CO4: Formulate region of interest through morphological operations.
- CO5:Evaluate strongly co-related regions obtained through Segmentation using discontinuity and homogeneity based segmentation techniques
- CO6: Describe an object of an image using Shape Number and Boundary descriptors.

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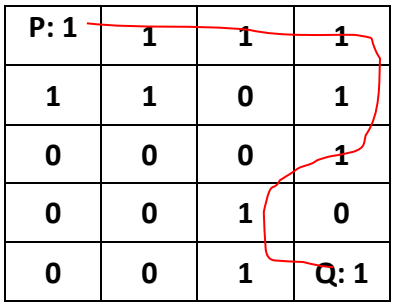
Mid Term Examination, Even Semester 2021-22
B.Tech (CSE), III Year, VI Semester
BCSE 0101: Digital Image Processing

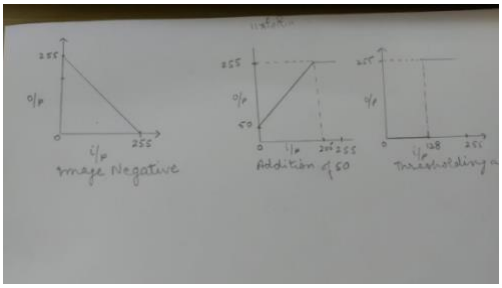
Time: 2 Hours **Maximum Marks: 30**

Instruction for students:
1. Use of calculators is allowed.
2. Clearly mention if any assumptions are being made.

Section – A

3 X 5 = 15 Marks

No.	Detail of Question	Marks	CO	BL	KL
1	Consider the following 1 bit image. **P: 1 1 1 1** **1 1 0 1** **0 0 0 1** **0 0 1 0** **0 0 1 Q: 1** **a.** Draw the m-adjacency path from pixel P to pixel Q where V={1} **b.** Calculate City Block Distance between P and Q. **c.** Find the size of the given image.  City Block distance = |0 – 3| + |0 – 4| = 7 Size = 5 x 4 = 20 bits	[1 + 1 + 1 = 3]	1	A	C
2	**Attempt both parts** **a.** Suppose there is a multispectral image of size 100 x 100. This image has 4 bands and each band is using 256 gray levels. This image needs to be transmitted at the rate of 10K bits per second. Calculate the time required to transmit the image in seconds. Total no. of bits = 100 x 100 x 4 x 8 Total time required = 100 x 100 x 4 x 8 / 10000 = 32 sec	[1.5 + 1.5]	1	A	C

	b. How many different 100 x 100 binary images can exist? 2^{10000}				
3	**Attempt any one** i. An 8-bit digital image has a histogram where the gray levels are equally distributed in the range from 160 to 220. For each operation of the following transformation functions, describe the gray level range in which the pixels will lie. Also draw the transformation function for each. In each case a gray level image will be generated where the gray level cannot be less than 0 or more than 255. **a.** Image negative **b.** Addition of 50 to all pixel gray levels **c.** Application of a thresholding function where the threshold is selected as gray level 128. **a.** Image Negative : 255 – 220 = 35; 255 – 160 = 95 **b.** Addition of 50 to all pixel gray levels : 160 + 50 = 210; 205 + 50 = 255. All intensities between 206 & 220 will be made 255. **c.** Application of a thresholding function where the threshold is selected as gray level 128 : All intensity values between 160 to 220 will be changed to 255.  ii. A certain image has 11 gray level intensities in the range of 10 to 20. If we generate a linear contrast stretched image with minimum gray level 0 and maximum gray level 7, then how will the new intensities get mapped? Write the formula and show the mapping in a tabular format as shown below. Note: Intensity values are always integers. So apply rounding off when required. $s = \frac{r - r_{min}}{r_{max} - r_{min}}(s_{max} - s_{min}) + s_{min}$ $s = \frac{r - 10}{20 - 10}(7 - 0) + 0 = \frac{r - 10}{10}. 7$	[1 + 1 + 1]	2	An	P

r	s	After rounding
⋮	⋮	⋮

r	s	After rounding
10	0	0
11	.7	1
12	1.4	1
13	2.1	2
14	2.8	3
15	3.5	4
16	4.2	4

		17	4.9	5				
		18	5.6	6				
		19	6.3	6				
		20	7	7				
4	**Attempt any one** i. Consider the following image. 0 1 0 2 7 2 1 6 1 0 5 6 7 6 3 1 1 6 1 5 5 4 2 2 5 What will be the new value of the pixel (2, 2) if smoothing is done using a 3 x 3: a) Mean filter **[½]** b) Weighted average filter (Assign weights as 3, 2 and 1) **[1]** c) Median filter **[½]** d) Min filter **[½]** e) Max filter **[½]** a) Mean filter 3.88 ~ 4 b) Weighted average filter 4.86 ~ 5 (Assign weights as 3, 2 and 1) c) Median filter 6 d) Min filter 1 e) Max filter 7 ii. Consider the following 4 bit, 4 x 4 image. 4 9 1 0 1 2 5 7 5 1 2 15 2 4 6 7 **a.** Extract the 0th Bit Plane. **b.** How will the image look if thresholding is set at 3? The output image should still be a 4 bit image.	3	2	A	C

0	1	1	0
1	0	1	1
1	1	0	1
0	0	0	1

15	15	0	0
0	0	15	15
15	0	0	15
0	15	15	15

5	**Attempt both parts** **a.** Give the transfer function of Gaussian Low pass and High pass filter. **b.** Compute the convolution of the Laplacian kernel L_4 with the image given below. Use border values to extend the image. **50 50 50 50 50** **50 50 50 50 50** **10 10 10 10 10** **10 10 10 10 10** **10 10 10 10 10** Gaussian Low Pass Filter $H(u,v) = e^{-D^2(u,v)/2D_0^2}$ GHPF $H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2}$ Instead of D_0 , σ can also be written	[1 + 2 = 3]	3	A	C

0	**0**	**0**	**0**	**0**	**0**
-40	**-40**	**-40**	**-40**	**-40**	**-40**
40	**40**	**40**	**40**	**40**	**40**
0	**0**	**0**	**0**	**0**	**0**
0	**0**	**0**	**0**	**0**	**0**
If Centre value: -4					

0	**0**	**0**	**0**	**0**	**0**
40	**40**	**40**	**40**	**40**	**40**
-40	**-40**	**-40**	**-40**	**-40**	**-40**
0	**0**	**0**	**0**	**0**	**0**
0	**0**	**0**	**0**	**0**	**0**
If Centre value: 4					

Section – B

5 X 3 = 15 Marks

No.	Detail of Question	Marks	CO	BL	KL
1	Perform histogram equalization on the following 8x8 image. The gray level distribution of the image is given below. Give your answer in tabular form as shown below.	5	2	A	P

Gray levels (r_k)	0	1	2	3	4	5	6	7
Number of pixels (p_k)	8	10	10	2	12	16	4	2

i/p Gray Level (r_k)	No. of pixels (n_k)	$p(r_k) = n_k / MN$	Σ	(L-1) Σ (S_k)	o/p Gray Level	No. of pixels in o/p image
⋮	⋮	⋮	⋮	⋮	⋮	⋮

i/p Gray Level (r_k)	No. of pixels in i/p image (n_k)	$p(r_k) = n_k / MN$	Σ	(L-1) Σ	o/p Gray Level (S_k)	No. of pixels in o/p image
0	8	0.125	0.125	0.875	1	8
1	10	0.15625	0.28125	1.96875	2	10
2	10	0.15625	0.4375	3.0625	3	12
3	2	0.03125	0.46875	3.28125	3	
4	12	0.1875	0.65625	4.59375	5	12
5	16	0.25	0.90625	6.34375	6	16
6	4	0.0625	0.96875	6.78125	7	6
7	2	0.03125	1	7	7	

2

Attempt any one

i. Consider the following image strip of 19 pixels. Compute its First order and second order derivatives.

6	6	6	6	5	4	3	2	1	1	1	1	1	1	6	6	6	6	6

Your answer should be in a tabular format having 3 rows as shown below. First row should show original signal, second row should have values of the First Order Derivatives and the third row should have values of Second Order Derivatives.

6	6	6	6	5	4	3	2	1	1	1	1	1	1	6	6	6	6	6

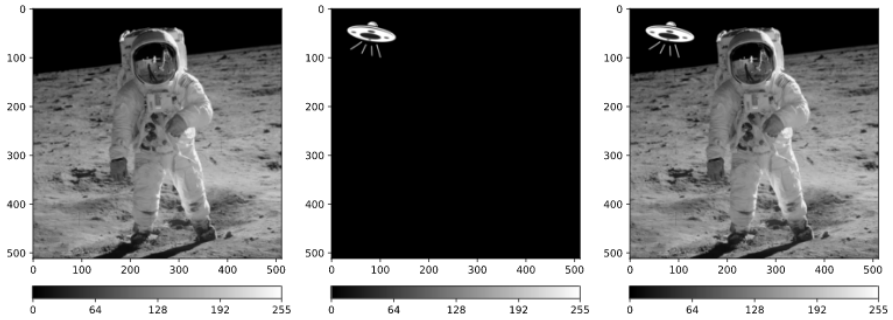
	6	6	6	6	5	4	3	2	1	1	1	1	1	1	6	6	6	6	6
f(x+1)-f(x)	0	0	0	-1	-1	-1	-1	-1	0	0	0	0	0	5	0	0	0	0	
f(x) – f(x-1)		0	0	0	-1	-1	-1	-1	-1	0	0	0	0	0	5	0	0	0	0
f(x+1)+ f(x-1) - 2f(x)		0	0	-1	0	0	0	0	1	0	0	0	0	5	-5	0	0	0	

5 | 2 | E | P

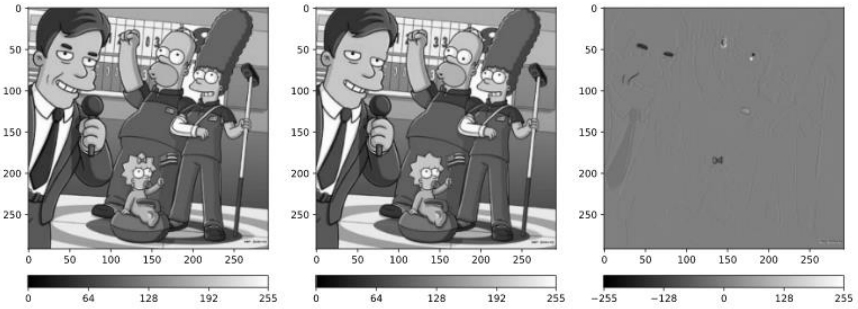
ii. Consider the following two set of images. The images on the right are the result of applying arithmetic operations between the two images on the left and in the middle. Specify which arithmetic operation has been used on Set1 and which on Set 2. Hint: Division operation has not been used on any Set. Give your answer by filling up the following blanks.

Set 1: _____

Set 2: _____



Set 1



Set 2

Set 1: Addition

Set 2: Subtraction

3

Compute the row wise Fourier transform of the following image, i.e. compute F(0, v), F(1, v), F(2, v) and F(3, v)

1	0	0	0
0	0	2	0
0	0	1	0
0	0	0	0

The coefficient could be ¼, ½, or 1. All answers are correct.

$$F(0,v) = \frac{1}{4}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix}\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \frac{1}{4}\begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

$$F(1,v) = \frac{1}{4}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix}\begin{bmatrix} 0 \\ 0 \\ 2 \\ 0 \end{bmatrix} = \frac{1}{4}\begin{bmatrix} 2 \\ -2 \\ 2 \\ -2 \end{bmatrix}$$

$$F(2,v) = \frac{1}{4}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix}\begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix} = \frac{1}{4}\begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix}$$

5 | 3 | A | P

	$$F(3,v)=\frac{1}{4}\begin{bmatrix}1 & 1 & 1 & 1\\ 1 & -j & -1 & j\\ 1 & -1 & 1 & -1\\ 1 & j & -1 & -j\end{bmatrix}\begin{bmatrix}0\\0\\0\\0\end{bmatrix}=\begin{bmatrix}0\\0\\0\\0\end{bmatrix}$$ $$F(x,v)=\frac{1}{4}\begin{bmatrix}1 & 1 & 1 & 1\\ 2 & -2 & 2 & -2\\ 1 & -1 & 1 & -1\\ 0 & 0 & 0 & 0\end{bmatrix}$$				

Instructions for Paper Setter:

- Internal choice can be given amongst the questions having same cognitive level of Bloom's Taxonomy.
- Each marks maps to Four Minutes of time. Questions must have sufficient content and depth accordingly.
- It is desirable that few questions of Mid and End Term should have higher order cognitive levels of BT and Knowledge Levels.

CO – Course Outcome, BL – Abbreviation for Bloom's Taxonomy Level (R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, C-Create), KL – Abbreviation for Knowledge Level (F-Factual, C-Conceptual, P-Procedural, M-Metacognitive). However, For Engg. Courses in addition to F, C, P & M include D-Fundamental Design Principles, S-Criteria and Specifications, PC-Practical Constraints, DI- Design Instrumentalities