CBCS SCHEME

USN | | | | | | | | | | |

15EC72

Seventh Semester B.E. Degree Examination, July/August 2021
Digital Image Processing

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions.

1 a. Explain the fundamental steps in digital image processing along with a block schematic. **(08 Marks)**

b. Define horizontal neighbors, vertical neighbors and diagonal neighbors for pixel p(x, y). Also determine the three distance measures between p(x, y) and q(s, t) in Fig.Q1(b), where coordinate starts with (0, 0) in this grayscale image.

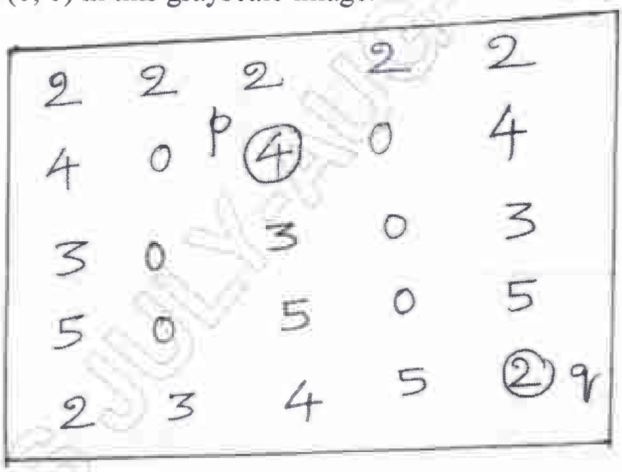

Fig.Q1(b) **(08 Marks)**

2 a. Explain image acquisition using single sensor, sensor strips and sensor arrays with relevant diagrams. **(09 Marks)**

b. Explain 4-adjacency, 8-adjacency and a region, linear and non-linear operators in image processing, for a 2-dimensional image with an example for each. **(07 Marks)**

3 a. Explain image negative, log transformation and power-law transformation with equations and figures. **(06 Marks)**

b. Explain historgram equalization for the given set of values in Table.Q3(b), determine the equalized histogram for a 3-bit image of size 64 × 64 pixels.

K	0	1	2	3	4	5	6	7
r_K	0	1	2	3	4	5	6	7
n_K	790	1023	850	656	329	245	122	81

Table.Q3(b) **(10 Marks)**

4 a. Explain the 7 steps used for filtering in the frequency domain. Define 2-D convolution theorem. **(06 Marks)**

b. Describe image sharpening using the following frequency domain filters:
(i) Ideal highpass filter
(ii) Butterworth highpass filter
(iii) Gaussian highpass filter **(10 Marks)**

5 a. Explain Gaussian, Rayleigh and Erlang noise models with equations and graphs. **(06 Marks)**
b. Describe adaptive local noise reduction filter and adaptive median filter used for removing noise in images. **(10 Marks)**

6 a. Explain arithmetic mean, geometric mean and median filter with equations and their usage for noise removal in images. **(06 Marks)**
b. Describe bandreject, bandpass and notch filters used for reduction of periodic noise with equations and figures. **(10 Marks)**

7 a. Explain the RGB color model with a cube structure and color equivalent values. Write the equations to convert RGB to HIS and HIS to RGB for color components. **(10 Marks)**
b. Briefly explain the subband coding with a block diagram of a simple digital filter and impulse response for the input $f(n) = \delta(n)$. **(06 Marks)**

8 a. Explain erosion and dilation operations along with their duality equations and examples with images. **(08 Marks)**
b. Describe opening and closing operations along with their duality equations and examples with images. **(08 Marks)**

9 a. Explain how isolated points and lines can be detected in images using derivatives and Laplacian mask respectively. **(08 Marks)**
b. Describe Canny edge detection method with equations and figures. **(08 Marks)**

10 a. Explain boundary following and chain codes used for representation for describing regions. **(08 Marks)**
b. Describe the MPP algorithm and its illustration with an example of vertices. **(08 Marks)**

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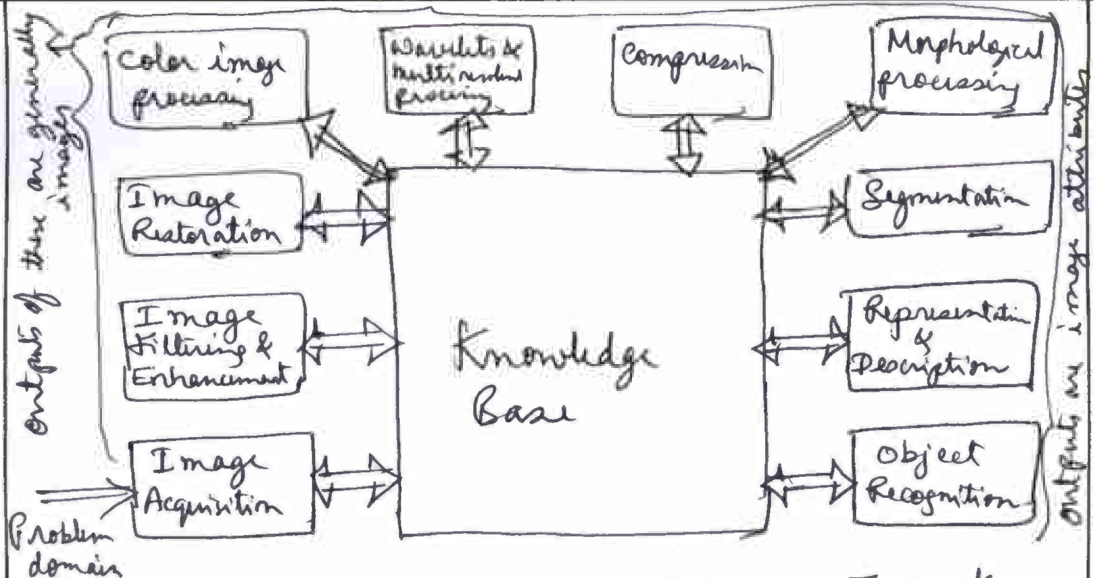
Signature of Scrutinizer

Scheme & Solution

Subject Title: Digital Image Processing **Subject Code:** 15EC72

Question Number	Solution	Marks Allocated
1 (a)		
	Figure - 3 marks Explanation = 5 marks	08
(b)	Horizontal neighbors of p: $(x, y-1)$ and $(x, y+1)$: 0 & 0	1M
	Vertical neighbors of p : $(x-1, y)$ and $(x+1, y)$: 2 & 3	1M
	Diagonal neighbors of p : $(x-1, y-1)$ $(x-1, y+1)$ $(x+1, y-1)$ $(x+1, y+1)$: 2, 2, 0 and 0	1M
	Euclidean distance between $p(x,y) = p(1,2)$ and $q(s,t) = q(4,4)$	
	$D_e(p,q) = \sqrt{(x-s)^2 + (y-t)^2}$ $= \sqrt{(1-4)^2 + (2-4)^2} = \sqrt{13}$	2M
	City Block (D_4) distance = $D_4(p,q) = \lvert x-s \rvert + \lvert y-t \rvert$ $= 3 + 2 = 5$	2M
	Chessboard (D_8) distance = $D_8(p,q) = \max(\lvert x-s \rvert, \lvert y-t \rvert)$ $= \max(3, 2) = 3$	1M
	Total =	08 M

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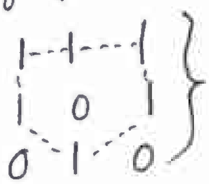
Question Number	Solution	Marks Allocated
2 (a)	Image acquisition using a single sensor : Fig 1, Ep-2 Image acquisition using sensor strips : Fig 1, Ep-2 Image acquisition using sensor arrays : Fig 1, Ep-2	3X3=9
(b)	4-adjacency : 2 pixels p and q with values from V are 4-adjacent if q is in the set $N_4(p)$ 1 1 1p 1 0 0q 0 1 1	1M
	8-adjacency : 2 pixels p and q with values from V are 8 adjacent if q is in set $N_8(p)$ 1 1 1p 1 0 0 q0 1 1	1M
	Region : R is a region of the image if R is a connected set, where R is a subset of pixels in an image  R_1	1M
	Linear operator: Given $H[f(x,y)] = g(x,y)$ where $f(x,y)$ is input image, $g(x,y)$ is output image. H is a linear operator if $H[a_i f_i(x,y) + a_j f_j(x,y)] = a_i H[f_i(x,y)] + a_j H[f_j(x,y)]$ $= a_i g_i(x,y) + a_j g_j(x,y)$ Sum operator is a linear operator	2M
	Nonlinear operator: max is a nonlinear operator $f_1 = \begin{bmatrix} 0 & 2 \\ 2 & 3 \end{bmatrix}$ $f_2 = \begin{bmatrix} 6 & 5 \\ 4 & 7 \end{bmatrix}$ $\max\left\{(1)\begin{bmatrix} 0 & 2 \\ 2 & 3 \end{bmatrix} + (-1)\begin{bmatrix} 6 & 5 \\ 4 & 7 \end{bmatrix}\right\} = -2$	2M

$(1)\max\begin{bmatrix} 0 & 2 \\ 2 & 3 \end{bmatrix} + (-1)\max\begin{bmatrix} 6 & 5 \\ 4 & 7 \end{bmatrix} = -4$ Total = 7M

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Question Number	Solution	Marks Allocated
3 (a)	Image Negative : $s = L-1-r$	
	Log Transformation : $s = c \log(1+r)$	
	Power-law (gamma) transformation $s = c r^{\gamma}$	2×3=6M
(b)	Histogram equalization	

$s = T(r) \quad 0 \le r \le L-1$

$$s_k = T(r_k) = (L-1) \sum_{j=0}^{k} p_r(r_j) = \frac{L-1}{MN} \sum_{j=0}^{k} n_j$$

$k = 0, 1, 2, \dots, L-1$ 3M

r_k	n_k	$p_r(r_k) = \frac{n_k}{MN}$
$r_0 = 0$	790	0.19
$r_1 = 1$	1023	0.25
$r_2 = 2$	850	0.21
$r_3 = 3$	656	0.16
$r_4 = 4$	329	0.08
$r_5 = 5$	245	0.06
$r_6 = 6$	122	0.03
$r_7 = 7$	81	0.02

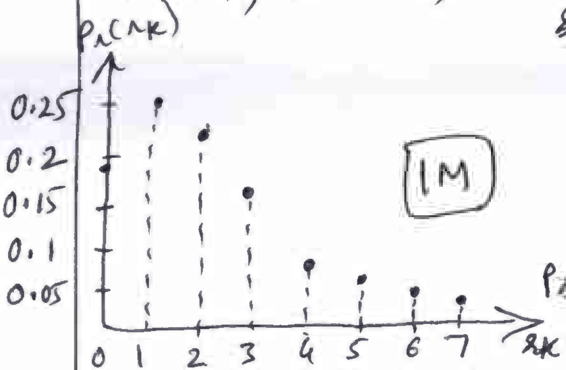
1M

$s_0 = 1.33 \rightarrow 1$
$s_1 = 3.08 \rightarrow 3$
$s_2 = 4.55 \rightarrow 5$
$s_3 = 5.67 \rightarrow 6$
$s_4 = 6.23 \rightarrow 6$
$s_5 = 6.65 \rightarrow 7$
$s_6 = 6.86 \rightarrow 7$
$s_7 = 7.00 \rightarrow 7$

2M

$K = 0, 1, 2, 3, 4, 5, 6, 7$

$M = 64, \ N = 64, \ M \times N = 4096$



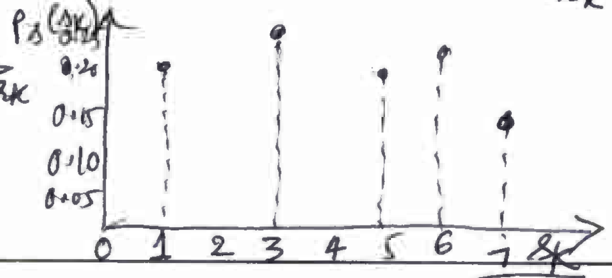
1M

1M

$p_s(s_1) = 0.19 \quad p_s(s_3) = 0.25$

$p_s(s_5) = 0.21 \quad p_s(s_6) = 0.24$

$p_s(s_7) = 0.109 = 0.11$



2M

10M

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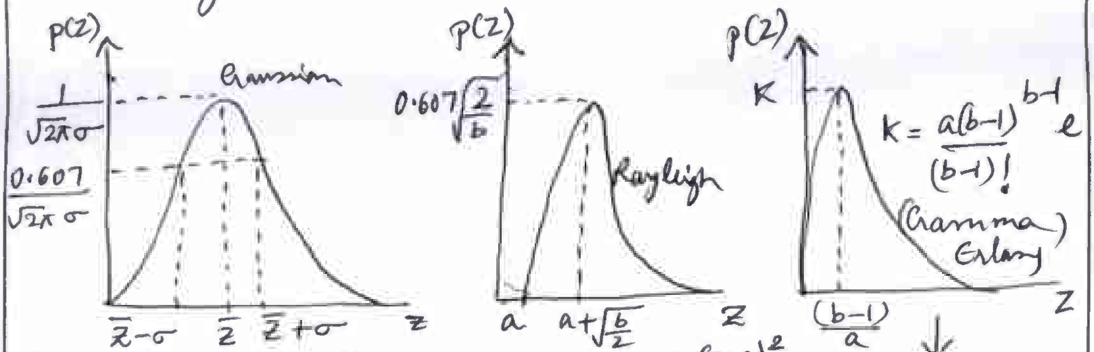
Question Number	Solution	Marks Allocated
4 (a)	Mentioning 7 steps in brief with relevant equations = 5M 2-D convolution Theorem = 1M $f(x,y) * h(x,y) \Leftrightarrow F(u,v)\,H(u,v)$	6M
(b)	Image sharpening using (i) Ideal Highpass filter $H(u,v) = \begin{cases} 0 & \text{if } D(u,v) \le D_0 \\ 1 & \text{if } D(u,v) > D_0 \end{cases}$ Figures & explanation **[4M]** (ii) Butterworth Highpass filter $H(u,v) = \frac{1}{1+[D_0/D(u,v)]^{2n}}$ Figures and explanation **[3M]** (iii) Gaussian highpass filter $H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2}$ Figures and explanation **[3M]**	10M
5 (a)	 Gaussian $p(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-(z-\bar{z})^2/2\sigma^2}$ Rayleigh $p(z) = \begin{cases} \frac{2}{b}(z-a)e^{-(z-a)^2/b} & \text{for } z \ge a \\ 0 & \text{for } z < a \end{cases}$ Erlang (Gamma) $p(z) = \begin{cases} \frac{a^b z^{b-1}}{(b-1)!} e^{-az} & \text{for } z \ge 0 \\ 0 & \text{for } z < 0 \end{cases}$	2×3 = 6M

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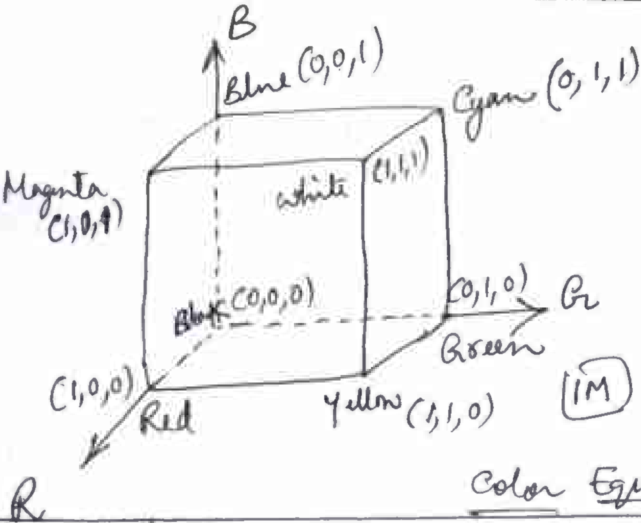
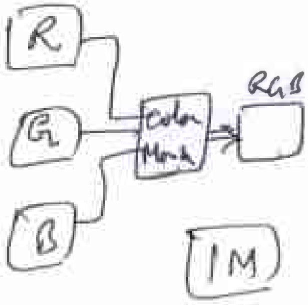
Question Number	Solution	Marks Allocated
5 (b)	Adaptive local noise reduction filter: Fig - [1M] Expln - [3M] $\hat{f}(x,y) = g(x,y) - \frac{\sigma_\eta^2}{\sigma_L^2}\left[g(x,y) - m_L\right]$ [1M]	5M
	Adaptive median filter: Stage A: $A_1 = Z_{med} - Z_{min}$, $A_2 = Z_{med} - Z_{max}$ If $A_1 > 0$ AND $A_2 < 0$, go to stage B else increase the window size. If window size $\leq S_{max}$ repeat stage A else output Z_{med}. Stage B: $B_1 = Z_{xy} - Z_{min}$, $B_2 = Z_{xy} - Z_{max}$ If $B_1 > 0$ AND $B_2 < 0$, output Z_{xy} else output Z_{med} Algorithm [2M], Fig - [1M], Expln = [2M]	5M 5+5=10M
6 (a)	Arithmetic mean filter: $\hat{f}(x,y) = \frac{1}{mn}\sum_{(s,t)\in S_{xy}} g(s,t)$ Geometric mean filter: $\hat{f}(x,y) = \left[\prod_{(s,t)\in S_{xy}} g(s,t)\right]^{\frac{1}{mn}}$ Harmonic mean filter: $\hat{f}(x,y) = \frac{mn}{\sum_{(s,t)\in S_{xy}} \frac{1}{g(s,t)}}$	2×3=6M
6 (b)	Bandreject filter: $H(u,v) = \begin{cases} 0 & \text{if } D_0 - \frac{W}{2} \leq D \leq D_0 + \frac{W}{2} \\ 1 & \text{otherwise} \end{cases}$ [3M] Bandpass filter: $H_{BP}(u,v) = 1 - H_{BR}(u,v)$ [4M] Notch filter: $H_{NP}(u,v) = 1 - H_{NR}(u,v)$ [4M] Eqn - 1M, Fig = 1M, Expln 1 or 2 Marks.	3+4+4=10

Subject Title: Digital Image Processing **Subject Code:** 15EC72

Question Number	Solution	Marks Allocated
7 (a)	see below	10M
7 (b)	see below	06

7 (a)





Color Equivalents [1M]

Hex	00	33	66	99	CC	FF
Decimal	0	51	102	153	204	255

RGB color model Expln - [3M]

RGB to HSI [2M]

$$H = \begin{cases} \theta & \text{if } B \le G \\ 360-\theta & \text{if } B > G \end{cases}$$

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{\frac{1}{2}}} \right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)]$$

$$I = \frac{1}{3}(R+G+B)$$

HSI to RGB [2M]

RG sector: $(0° < H < 120°)$

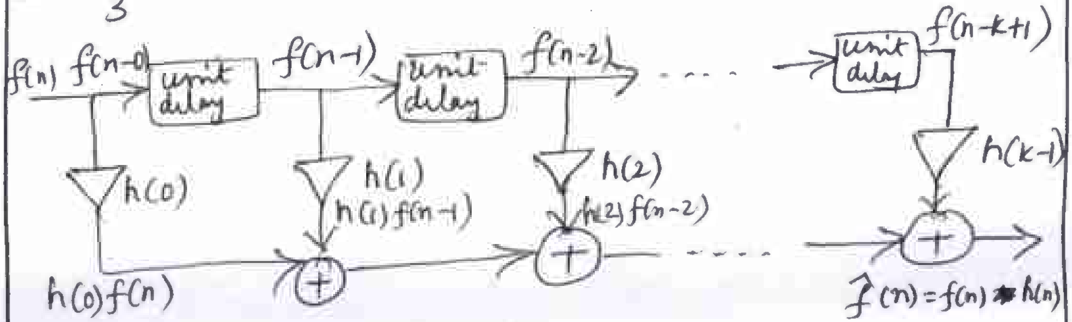
$$B = I(1-S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

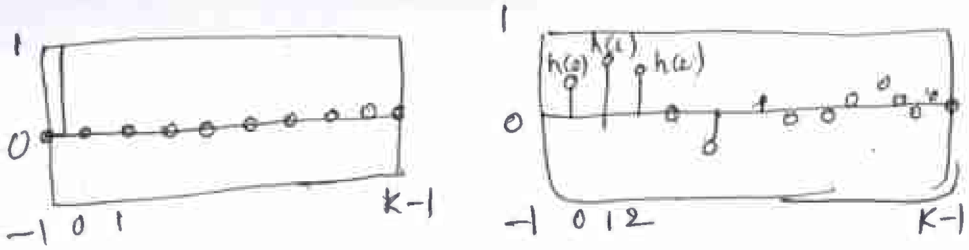
$$G = 3I - (R+B)$$

|||ly for GB sector & BR sector RGB & GBR formulae

7 (b)



$f(n) = \delta(n)$



Figs - 4M, Exp - 2M

Subject Title : Digital Image Processing | Subject Code : 15EC72

Question Number	Solution	Marks Allocated
8 (a)	Erosion: $(A - B) = \{z \mid (B)_z \subseteq A\}$ & figs, exp [3M] Dilation: $(A \oplus B) = \{z \mid (\hat{B})_z \cap A \neq \phi\}$ & figs, exp [3M] Duality: $(A \ominus B)^c = A^c \oplus \hat{B}$ $(A \oplus B)^c = A^c \ominus \hat{B}$ } [2M]	08
(b)	Opening: $A \circ B = (A \ominus B) \oplus B$ & figs, explr [3M] Closing: $A \bullet B = (A \oplus B) \ominus B$ & figs, explr [3M] Duality: $(A \circ B)^c = (A^c \bullet \hat{B})$ $(A \bullet B)^c = (A^c \circ \hat{B})$ } [2M]	08
9 (a)	Isolated points: Eqn - 2M, Eg - 1M, Exp - 1M Lines: Figs - 2M, Explr - 2M	4+4=8
(b)	Canny edge detection: Eqn - 2M, Fig - 2M, Exp - 4M	08
10 (a)	Boundary following: Fig - 2M, Exp - 2M Chain codes: Fig - 2M, Exp - 2M	4+4=8
(b)	MPP algorithm: Figs - 2M, Exp - 6M	08M