

# JK LAKSHMIPAT UNIVERSITY, JAIPUR

## INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular), November-December 2015

B. Tech in Computer Science Engineering, Semester VII

Subject Code: CSE 728

Roll No.....

Subject Name: Digital Image Processing

Time: 3 hours

Max. Marks: 100

### Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark) 10

- i. Digital images are displayed as a discrete set of  
(a) values (b) numbers (c) frequencies (d) intensities
- ii. Sensor strip is mounted in a ring configuration is used in  
(a) microscopy (b) medical (c) industry (d) radar
- iii. Imaging system produces  
(a) high resolution image (b) voltage signal  
(c) digitized image (d) analog signal
- iv. In bit plane slicing the most of the information of an image is contained by  
(a) highest order plane (b) lowest order plane (c) mid order plane (d) All planes
- v. Method generating a processed image having specified histogram is called  
(a) histogram enhancement (b) histogram normalization  
(c) histogram equalization (d) histogram matching
- vi. Which of the following is the correct match of the following two lists of terms:  
a. sampling theorem 1. aliasing  
b. image sharpening 2. Nyquist rate  
c. piecewise linear function 3. the Laplacian  
d. under sampling 4. intensity-level slicing  
(a) a-2, b-3, c-1, d-4 (b) a-4, b-3, c-2, d-1 (c) a-2, b-3, c-4, d-1 (d) a-2, b-4, c-3, d-1
- vii. A 4-point sequence  $\{f(0) f(1) f(2) f(3)\}$  is odd if it has the form  
(a)  $\{0 -b 0 b\}$  (b)  $\{a -b b c\}$  (c)  $\{b 0 -b 0\}$  (d)  $\{a b c b\}$
- viii. If  $F(u, v) = R(u, v) + jI(u, v)$ ,  $j = \sqrt{-1}$ , is the Fourier transform of an imaginary function  $f(x, y)$  [ $R(u, v)$  and  $I(u, v)$  are real and imaginary part of  $F(u, v)$ ]. Which of the following is FALSE:  
(a)  $F(u, v)$  is conjugate antisymmetric (b)  $R(u, v)$  is even,  $I(u, v)$  is odd  
(c)  $R(u, v)$  is odd,  $I(u, v)$  is even (d) if  $f(x, y)$  is even then  $F(u, v)$  is also even
- ix. Color pixel is  
(a) scalar (b) coordinate (c) vector (d) Both (a) and (b)
- x. Which of the following is FALSE w.r.t.  $L^* a^* b^*$  color space? It is -----  
(a) colorimetric (b) perceptually uniform  
(c) perceptually non-uniform (d) device independent

|      |                                                                                                                                                                                                    |    |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Q.2  | Short answer type questions (4 questions @ 2.5 marks)                                                                                                                                              | 10 |
| i.   | Represent the Weber ratio as a function of intensity through a plot and comment on brightness discrimination power of human visual system based on this plot.                                      |    |
| ii.  | Consider a 1-D function $f$ with a discrete unit impulse given as 0 0 0 1 0 0 0 0 and a filter $w$ given as 2 4 6 4 8. Obtain the results of correlation of the filter $w$ with the function $f$ . |    |
| iii. | Briefly discuss the translation and rotation properties of the 2-D DFT.                                                                                                                            |    |
| iv.  | Show that Fourier transform of a real function $f(x, y)$ is conjugate symmetric i.e. $F^*(u, v) = F(-u, -v)$ .                                                                                     |    |

|      |                                                                                                                                                                       |    |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Q.3A | Illustrate the process of digital image acquisition using array sensors.                                                                                              | 05 |
| Q.3B | Consider the image segment shown. Let $V=\{1, 2\}$ and compute the Euclidian, $D_4$ (City-block), $D_8$ (Chessboard) and $D_m$ distance metrics between $p$ and $q$ . | 05 |

|         |   |   |   |          |
|---------|---|---|---|----------|
|         | 3 | 1 | 2 | 1( $q$ ) |
|         | 2 | 2 | 0 | 2        |
|         | 1 | 2 | 1 | 1        |
| ( $p$ ) | 1 | 0 | 1 | 2        |

|      |                                                                                                                                                                                                                            |    |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Q.4A | Briefly describe the following intensity transformations:                                                                                                                                                                  | 05 |
| i.   | Power-law transformation                                                                                                                                                                                                   |    |
| ii.  | Intensity-level slicing                                                                                                                                                                                                    |    |
| Q.4B | How do we implement first-order derivatives in image processing to perform nonlinear image sharpening? Give the mathematical expressions and corresponding masks for Roberts cross-gradient operators and Sobel operators. | 05 |

|      |                                                                                                                                                                                   |  |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Q.5A | The following figure shows respectively a 3-bit image of size $5 \times 5$ image in the square with $x$ and $y$ coordinates specified, a Laplacian filter, and a low-pass filter. |  |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

| $y \backslash x$ | 0 | 1 | 2 | 3 | 4 |
|------------------|---|---|---|---|---|
| 0                | 3 | 7 | 6 | 2 | 0 |
| 1                | 2 | 4 | 6 | 1 | 1 |
| 2                | 4 | 7 | 2 | 5 | 4 |
| 3                | 3 | 0 | 6 | 2 | 1 |
| 4                | 5 | 7 | 5 | 1 | 2 |

| Laplacian filter |    |   |
|------------------|----|---|
| 0                | 1  | 0 |
| 1                | -4 | 1 |
| 0                | 1  | 0 |

| Low pass filter |      |      |
|-----------------|------|------|
| 0.01            | 0.1  | 0.01 |
| 0.10            | 0.56 | 0.10 |
| 0.01            | 0.1  | 0.01 |

Determine the following:

|      |                                                                                         |    |
|------|-----------------------------------------------------------------------------------------|----|
| i.   | The output of the $3 \times 3$ median filter at (2, 2).                                 | 01 |
| ii.  | The output of the $3 \times 3$ Laplacian filter shown above at (2, 2).                  | 01 |
| iii. | The output of the $3 \times 3$ low pass filter shown above at (2, 2).                   | 01 |
| iv.  | The normalized histogram of the whole image.                                            | 02 |
| Q.5B | Consider the above shown $5 \times 5$ image as input image and determine the following: |    |
| i.   | The output $5 \times 5$ histogram equalized image.                                      | 03 |
| ii.  | The equalized histogram.                                                                | 02 |

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |    |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Q.6A | Find the Fourier transform, $F(\mu)$ , of the function $f(t)$ defined as follows:<br>$f(t) = \begin{cases} A, & \text{for } -W/2 \leq t \leq W/2 \\ 0, & \text{otherwise} \end{cases}$ <p>Also show the plots of <math>F(\mu)</math> and <math> F(\mu) </math> as a function of frequency <math>\mu</math>.</p>                                                                                                                                                                                                                | 05 |
| Q.6B | Show that the Fourier transform, $S(\mu)$ , of an impulse train, $S_{\Delta T}(t)$ , with period $\Delta T$ is also an impulse train, whose period is $1/\Delta T$ .                                                                                                                                                                                                                                                                                                                                                           | 05 |
| OR   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |    |
| Q.6B | Why do we need to perform sampling? Use an impulse train $S_{\Delta T}(t)$ as the sampling function, describe the procedure (pictorially and mathematically) of obtaining the samples at uniform intervals $\Delta T$ for a continuous function $f(t)$ .                                                                                                                                                                                                                                                                       | 05 |
| Q.7A | Determine whether the 1-D discrete function $f(x) = \{f(0) \ f(1) \ f(2) \ f(3)\} = \{2 \ 1 \ 1 \ 1\}$ and its Fourier transform $F(u)$ are even or odd.                                                                                                                                                                                                                                                                                                                                                                       | 05 |
| Q.7B | If $1 \Leftrightarrow \delta(u, v)$ means the Discrete Fourier Transform (DFT) of 1 is a 2-D discrete impulse $\delta(u, v)$ in frequency domain and inverse discrete Fourier transform of $\delta(u, v)$ is 1. Using the translation property of 2-D DFT, show that the DFT of the discrete function $f(x, y) = \sin(2\pi u_0 x + 2\pi v_0 y)$ is<br>$F(u, v) = \frac{j}{2} [\delta(u + Mu_0, v + Nv_0) - \delta(u - Mu_0, v - Nv_0)]$ ,<br>where $j^2 = -1$ and $M \times N$ is the size of the function (image) $f(x, y)$ . | 05 |
| OR   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |    |
| Q.7B | Explain the image enhancement (sharpening) using the Laplacian in the frequency domain.                                                                                                                                                                                                                                                                                                                                                                                                                                        | 05 |
| Q.8A | How image smoothing is performed in frequency domain? Explain the commonly used image smoothing filters in frequency domain.                                                                                                                                                                                                                                                                                                                                                                                                   | 10 |
| Q.9A | Explain the following pseudocolor image enhancement techniques:                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 10 |
|      | i. Intensity (density) slicing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |    |
|      | ii. Intensity to color transformations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |    |
| Q.9B | In the context of color transformations, elaborate the following concepts:                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 10 |
|      | i. Mathematical model of color transformation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |    |
|      | ii. Color complements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
|      | iii. Color slicing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |    |
| OR   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |    |
| Q.9B | Write short note on the following: (any two)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 10 |
|      | i. Components of an image processing system                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |
|      | ii. Application areas of DIP                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |    |
|      | iii. CIE $L^* a^* b$ model                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |    |
|      | iv. Color image smoothing and sharpening                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |    |