Indian Institute of Technology, Kharagpur
Mid-Semester Examination (Autumn 2021-22)
Image Processing (CS 40019)
Date : 21st Sept 2021 (8.15 – 9.45 AM) Marks = 40

Note: Answer all questions
Write answers using pen and paper, and mail the scanned copy to your respective TA before 9.55 AM.
Late submissions will be penalized.
Write all intermediate steps and results while solving the problems
If you consider any assumptions, please mention them in the answer script

1. Answer the following: **(3+1+1=5M)**

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

Image Processing Application	**Energy Source**
(i) Silicon Photolithography	(a) Gamma Rays
(ii) Weather Prediction	(b) X-Rays
(iii) Positron Emission Tomography	(c) Ultra-Violet
(iv) Space-borne Radar	(d) Visible and Infrared
(v) Magnetic Resonance Imaging	(e) Microwaves
(vi) Traffic monitoring & Surveillance	(f) Radio Waves
	(g) Sound Waves
	(f) Electron Beam

(b) If you use a sheet of white paper to shield your eyes when looking directly at the sun, the side of the sheet facing you appears black. The same sheet appears white, when it is placed on the desk. Which of the visual processes is responsible for this?

(c) When you enter a dark room on a bright day, it takes an appreciable interval of time, before you can see well enough the objects present in that room. Which of the visual processes is responsible for this?

2. A CCD camera chip of dimensions 7 × 7 mm and 1024 × 1024 sensing elements, is focused on a square, flat area, located 0.5 m away. The camera is equipped with a 35-mm lens. What is the size of the square? How many line pairs per mm will this camera be able to resolve? **(4M)**

3. A common measure of transmission for digital data is the baud rate, defined as symbols (bits in our case) per second. As a minimum, transmission is accomplished in packets consisting of a start bit, a byte (8 bits) of information, and a stop bit. How many seconds would it take to transmit a sequence of 500 images of size 1024 × 1024 pixels with 256 intensity levels using a 3 M-baud (10^6 bits/sec) modem? **(2M)**

4. We need to perform certain geometric transformation on the original image to generate the desired target image. For one of the pixels in the transformed image, its corresponding location in the original image is found to be at (11, 13), by applying the inverse mapping. Assume that the spacing between the pixels in the original image is 5 units. Find the locations of four nearest neighbors to the mapped pixel located at (11, 13). The gray values (intensities) of the four neighbors are 120, 140, 160 and 180, respectively, in the increasing order of their proximity (distance) from the mapped pixel. Determine the gray level (intensity) of the mapped pixel using Bi-linear Interpolation. **(5M)**

5. Consider two sub-images K1 and K2 whose size is 4 × 4. Consider the intensity set V = {0,1,2,3}. **(4+6=10M)**

K1				K2			
1	4	13	4	3	1	5	0
2	1	3	2	1	7	1	11
3	8	1	6	1	2	1	2
10	1	2	1	14	3	5	9

(a) Determine whether the sub-images K1 and K2 are (i) 4-adjacent, (ii) 8-adjacent, or (iii) m-adjacent. Mention all possibilities for each case, and justify each of your claim.

(b) Compute how many 4-, 8- and m- paths exist between the corner pixels of the principle diagonal (top-left corner and bottom-right corner pixels) of the sub-image K1. Mention all paths and their lengths using the sequence of intensities. Identify the shortest path and determine its length in each case (4-, 8- and m- cases) and also mark them using sequence of intensity values. If, path doesn't exists in any one of the cases, specify the same with justification.

6. Perform the arithmetic operation ADDITION on the sub-images K1 and K2. Assume that intensity values are encoded with 4-bits. After performing the operation show the resultant scaled image (by showing the intensity values in 4 × 4 format). **(3M)**

7. Perform the following SET operations on the sub-images K1 and K2: (i) Complement of K1, (ii) Union of K1 and K2 and (iii) Intersection of K1 and K2. **(3M)**

8. Design a single intensity transformation function for spreading the intensities of an image, such that the lowest intensity is 0 and the highest is $L - 1$. Apply the above designed intensity transformation function on the sub-image K1, where the number of intensity levels in the transformed image to be 30. **(3M)**

9. On the sub-image K1, the following intensity transformations are applied. (i) Plot the intensity transformation functions and (ii) Determine the transformed image in each case.
(a) Intensity threshold function with the threshold intensity equal to 5.
(b) $T(r) = r$ (if $r < 4$ or $r > 8$) and $T(r) = 15$ (otherwise) **(5M)**