Reg. No.											

MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal 576104)

VII SEM B.Tech (BME) DEGREE END-SEMESTER EXAMINATIONS, NOV-DEC 2018.

SUBJECT: ADVANCED IMAGE PROCESSING (BME 4102)
(REVISED CREDIT SYSTEM)
Tuesday, 20Th November, 2018, 2 to 5 PM

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to Candidates:

1. **Answer ALL questions.**
2. **Read all the questions carefully, and answer *adequately*, but *to the point*.**
3. **Draw labeled diagram wherever necessary**

1. (a) Consider $\boldsymbol{y} = \boldsymbol{Ux}$, where $\boldsymbol{x}$ is a 3-element vector, and $\boldsymbol{U}$ is a 3×3 *unitary* matrix. Prove that $\boldsymbol{U}$ rotates $\boldsymbol{x}$, or satisfies Parseval's theorem. (2)

(b) Consider a (continuous) image $f_1(a,b)$, whose intensity may be modeled by a random variable (RV) X, known to be distributed between $[x_1,x_2]$, although the shape of the density $f_X(x)$ is not known. Let $f_2(a,b)$ the image obtained by a gray-level transformation of $f_1(a,b)$ *i.e.*, if Y is the RV representing the intensities in $f_2(a,b)$, $Y = T\{\mathrm{f(X)}\}= g(\mathrm{X})$.

(i) If the function $g(x)$ has two roots, write down the expression for $f_Y(y)$, in terms of $f_X(x)$ and of course, $g(x)$.

(ii) Consider the case in which T has a single root, and $f_Y(y)$ turns out to be uniform on the interval $[x_1,x_2]$. Answer the following questions: (3)

- find the expression for the transformation, T.
- sketch $\mathrm{P}\{Y \le y\}$, as a function of y.

(c) (i) Consider the image in terms of numerical values in Figure 1. Perform histogram equalization of the image, to find out if the contrast can be improved when it is displayed on a monitor. (4)

(ii) If you are told that the just noticeable difference for an observer is 2 units, do you think that the processing would help a better visualization when displayed on the monitor? (1)

2. (a) Consider the transformation: $Y(k) = \sum_{n=0}^{N-1} x(n) a_k(n), \quad 0 \le k < N-1$. If the kernel of the transform is given by: $a_k(n) = \frac{1}{\sqrt{N}} e^{j\frac{2\pi}{N}kn}$.

(i) Write down the 3×3 transformation matrix (N=3), with numerical (complex) entries (2)

(ii) Show mathematically, *or numerically*, that the matrix is orthogonal (orthonormal). (2)

(b) Explain from the fundamentals, the development of the method of edge-detection by using (only) the Laplacian. The method should not detect trivial (insignificant) changes. (4)

(c) (i) Is the algorithm robust to the presence of noise? Why?
(ii) If not, how would you make it robust to the presence of noise? (2)

3. (a) (i) An X-ray technician wanted someone to develop a program to detect the presence of ribs in chest-radiographs. He agrees to give you digital images of the radiographs (of size 2048×2048) for the purpose. On obseving that the shape of the ribs is in the form of curves that may be represented by the equaltion: $y = ax^2 + bx + c$ (in general), you agree. Write a *pseudo-code* to detect the presence of the ribs in the image. (4)

(ii) On converting the pseudo-code to a program and testing it on some images, the technician is happy. However, he urges you to speed up the program. Assuming that you had used the *gradient-based* edge-detection to first convert the image to an edge-map:
how would you use the information available (after running edge-detection), to speed up the execution of the program? Show clearly, the necessary changes in the pseudo-code in 3(a)(i), that would bring about the speed in implementation. (2)

(b) Let $s(n)$ be the poits along a closed boundary associated with an object. Derive the effects of (i) translation, (ii) rotation, and (iii) scaling, of the object $f(x,y)$, *on the DFT of the bounday sequence* $s(n)$. Hint: Derive first, the effects of object-transformation on $s(n)$, and then on its DFT. (4)

4. (a) Sketch the results of *opening* and *closing* of the object shown in Fig. 2(a), by the structuring element shown in Fig. 2(b). All the intermediate steps and the associated details/dimensions must be shown clearly. (4)

(b) (i) Prove mathematically, that the central moment: $\mu_{1,0} = 0$. (2)

(ii) What are the advantages of moment-based invariants, over those based on the Fourier descriptors? (2)

(iii) Explain at least two practical instances giving rise to blurring of an object in an image. Can you construct numbers (features) invariant to blur? What are the basic features that you would use, to construct such invariants? (2)

5. (a) (i) Explain briefly, the practical circumstances under which adaptive thresholding becomes required. (1)

(ii) Sketch a rough image of your choice, exhibiting the circumstances that you have referred to in the preceding question, clearly. (1)

(iii) Explain an adaptive thresholding method of your choice, that works, to segment the image from the background appropriately. Show how it works on the image that you have sketched (in the preceding question). (3)

(b) (i) Explain the concepts of hue, saturation and intensity (in the context of HSI model in image processing), and indicate at least one advantage of the HSI model with respect to the RGB model. (2)

(ii) Explain the complete procedure for wound-segmentation based on color, using the minimum-distance criterion. (3)

9	1	1	1	2	6	6	5
7	7	7	6	6	6	6	9
7	7	7	6	6	6	6	12
7	7	7	6	6	6	6	12
7	7	7	6	6	6	6	12
7	7	7	6	6	6	6	12
6	6	6	6	6	6	6	9
6	6	6	6	6	6	6	6

Figure 1 [Question 1(c)]

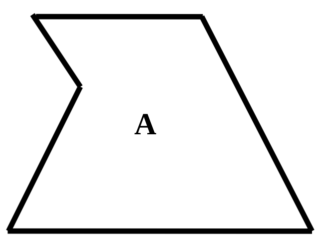

Figure 2 (a)

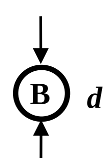

Figure 2 (b)

[Question 4(a)]