Reg. No.											

MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal 576104)

VII SEM B.Tech (BME) DEGREE END-SEMESTER EXAMINATIONS, NOV. 2019.

SUBJECT: ADVANCED IMAGE PROCESSING (BME 4102)
(REVISED CREDIT SYSTEM)
Friday, 15Th November, 2019, 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 a general *unitary* transform: $Y(k) = \sum_{n=0}^{N-1} x(n) a_k(n), \quad 0 \le k < N-1$.

Write down the equation for the inverse of the transform *i.e.*, for computing $x(n)$ from $Y(k)$. Justify your answer/steps. (2)

(b) Compute the *linear convolution* of the sequence, whose samples are the elements of the data-vector $\boldsymbol{x}$ = [12 10 7 8 9 4] (Note: the first element is the zeroth sample), and the impulse response $h(n)$: $h(0) = 0.7$; $h(1) = 0.2$; $h(2) = 0.1$, by using matrix representation of circular convolution. All the vectors and matrices involved (at all the stages of problem-solving) must be indicated clearly. (3)

(c) (i) Perform histogram equalization of the image in Fig. 1. (3)

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

Figure 1

(ii) Compute the entropy of the image in Fig. 1, and also of its histogram-equalized version. Comment on the results. (2)

2. (a) Develop from the fundamentals (with all the details), the convolution-masks (matrices) for computing the *Gradient* of an image (at each of the pixels). (4)

(b) Find the expression for the frequency-response of the gradient mask/matrix – <u>for finding the *X*-gradient</u>, and simplify it. (2)

(c) Is mere thresholding of the gradient-magnitude sufficient to get the edge image? Give reasons for your answer. If not, what else would you have to do *i.e.*, what other operation can you think of, to get a better edge-image? You may use illustrations in 1D. (2)

(d) Explain a method of *edge-thinning*, to eliminate spurious edges extracted from the technique you have developed in answer to the preceding question. (2)

3. (a) Certain objects in a medical image are approximately *elliptical*. Towards detecting the presence of ellipses in such images, write a *pseudo-code* based on the Hough-transform algorithm. An ellipse is of the form: (3)

$$\frac{(x-h)}{a^2}+\frac{(y-k)}{b^2}=1$$

in digital images. Restrict you search to ellipses with $a > 30$, $b > 20$.

(ii) Sketch the Hough-space pertaining to the image of a (half-) ellipse shown in Fig. 2; the *threshold for detecting its presence* is 45 – will this ellipse be detected? Justify the answer quantitatively. For your information, the expression for the perimeter of an ellipse is given by Ramanujan's approximation: $p \approx \pi[\,3(a+b)-\sqrt{(3a+b)(a+3b)}\,]$ (2)

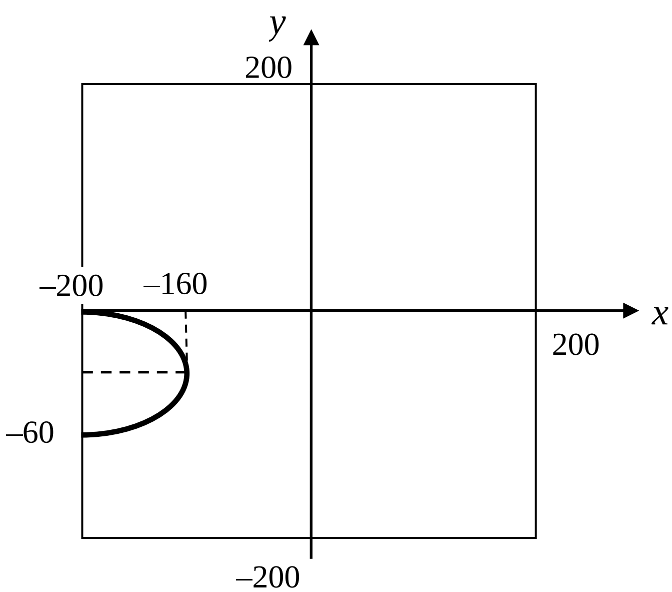

Figure 2

(b) Consider the moment-based expression: $\eta'_{p,q} = \frac{\mu_{p,q}}{\mu_{00}}\left[\frac{\mu_{0,2}+\mu_{2,0}}{\mu_{0,0}}\right]^{-\frac{(p+q)}{2}}$ (5)

Compute the values of $\eta'_{p,q}$, corresponding to the the objects shown in Fig. 3 (a) and 3 (b), respectively, for $p+q \leq 3$. The intensity inside the square object is 1.

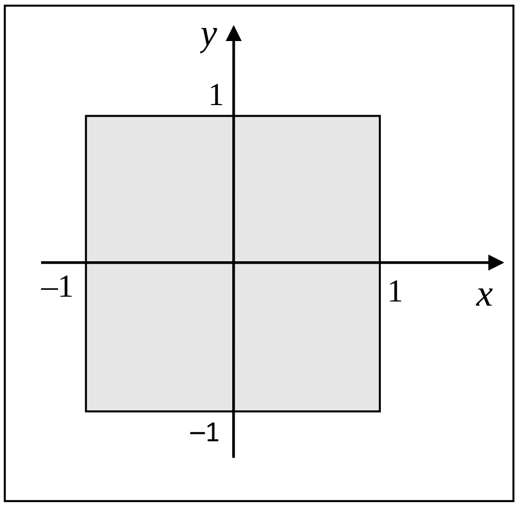

Figure 3(a)

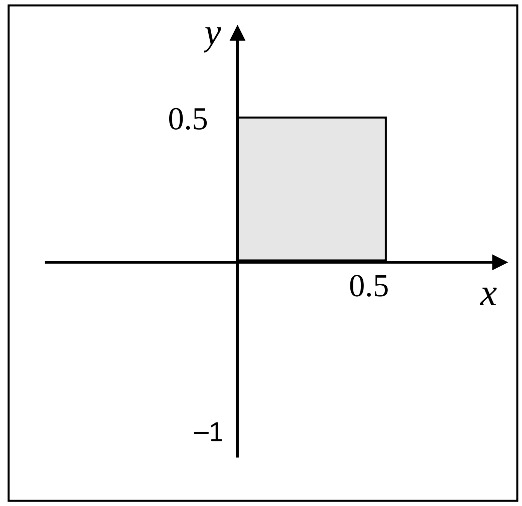

Figure 3(b)

4. (a) List all the desirable properties of *invariants*, and explain the significance of each, briefly. (4)

(b) Consider decision-making in a two-class problem by the minimum-distance rule, involving non-overlapping, spherically shaped clusters (with mean m_1 and m_2). The decision boundary, separating two classes, is given by the equation:

$$x^T(m_2 - m_1) - \frac{1}{2}(\| m_2 \|^2 - \| m_1 \|^2) = 0$$ (2)

where x denotes the input vector (*i.e.*, observation). Prove that the decision boundary is the *perpendicular-bisector* of the line joining the two classes.

(c) Sketch the approximate output of Top-hat and Bottom-hat transformations, on the profile sketched in Fig. 4, using the structuring element B (circular disc) sketched in the figure. NOTE: Top-hat transform: $C = A - A\text{o}B$; Bottom-hat transform: $D = (A \bullet B) - A$, where "o" and "•" represent morphological opening and closing, respectively. (4)

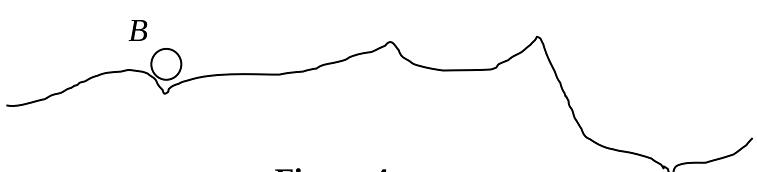

Figure 4.

5. (a) It is often sufficient to understand the concepts in image processing by analyzing the 1D case. Towards such an effort, consider the signal degradation-model represented by the equation: $g(n) = s(n) * b(n) + w(n)$, where $s(n)$ is the signal to be restored, $b(n)$ is the point-spread function representing blur, and $w(n)$ is a *white noise* sequence of variance σ^2.

(i) Write the expression for the filter to recover $s(n)$ in the absence of noise, so that the magnitude of the frequency-response does not exceed a pre-specified value. (1)

(ii) In the absence of blur:

- What is the expression for the frequency-response $H(\omega)$ of the Wiener filter designed to recover $s(n)$ from its noisy version? (1)
- If the frequency components of the signal $s(n)$ may be assumed to be non-zero within a low-frequency-band with cut-off at δ Hz, sketch roughly, the form of $|H(\omega)|$. Explain the logic behind the sketch of $|H(\omega)|$. (2)

(b) (i) Explain all the steps in color-based segmentation of candidate bacilli, from the images of ZN-stained sputum smears. (3)

(ii) Explain the *proximity-test algorithm*, required for identifying beaded-bacilli from the blobs that result from color-segmentation-step performed in the previous step. Assume that the maximum number of beads within a valid beaded-bacillus is 5. (3)