

**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJ)**

FIRST SEMISTER 2022-2023

Pattern Recognition (BITS F446)

Comprehensive Examination (Closed Book)

Maximum Marks: 120

Maximum time: 180 minutes

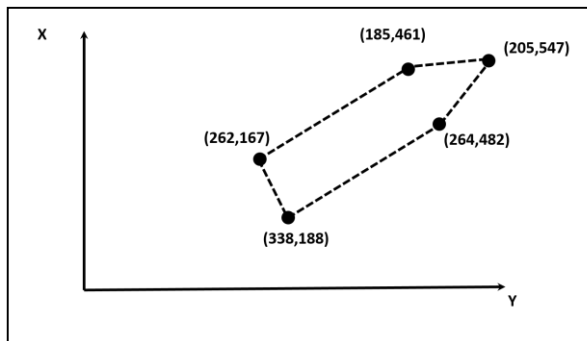
Date: 22/12/2022

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- Each symbol has its usual meaning
  - Answer to the point
  - Show the calculation steps. Showing final answer may not attract full marks.
  - Use fresh A4 page
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**Q1.** Three classes of sea creatures - megalodon, orca and giant squid are to be recognized by their length and width. The sample mean vectors are  $m_1 = \begin{pmatrix} 14.7 \\ 8.2 \end{pmatrix}$ ,  $m_2 = \begin{pmatrix} 6.7 \\ 3.1 \end{pmatrix}$  &  $m_3 = \begin{pmatrix} 1.9 \\ 0.8 \end{pmatrix}$ , respectively. Find the boundary decision functions. If a sample vector  $x = \begin{pmatrix} 3.0 \\ 2.6 \end{pmatrix}$ , find the class of this sample vector. Show that the line joining the points,  $m_1$  and  $m_2$  is perpendicular to the line of the corresponding boundary decision function. **[12+5+8]**

**Q2.** Write the mathematical expressions of the signature (normalize strictly wrt starting point) of an equilateral triangular boundary of side  $a$ . Plot the result for  $\theta = 0$  to  $360^\circ$  with proper labeling. **[10+5]**

**Q3.** Find the mean, covariance, eigenvectors and eigen values of the structure shown in the figure below. The five coordinates are shown in bracket as appearing in the image. The long principal axis of the structure is aligned  $30^\circ$  with respect to the Y-axis. **[6+8+8+8=30M]**



**Q4.** The signature of a circle is shown in form of data in the table below.

$\theta$	$0.0\pi$	$0.2\pi$	$0.4\pi$	$0.6\pi$	$0.8\pi$	$1.0\pi$	$1.2\pi$	$1.4\pi$	$1.6\pi$	$1.8\pi$	$2.0\pi$
$r(\theta)$	4.7	5.3	5.1	11.0	27.1	12.4	4.9	5.0	5.1	5.2	4.7

The noisy signature should be normalized appropriately so that the effect of noise should be reduced. Find out the normalized signature of the above mentioned circle and write the normalized values of  $r$  as a function of  $\theta$  varies from  $0$  to  $2\pi$  in the step of  $0.2\pi$  in the tabular form. Draw the normalized signature.

[15M]

**Q5.** Replace the character “t” with “l” in the given image of text. Given that “l” is a vertical line of height 20 pixels and width 3 pixels. In the given image, the heights of the long and short characters are 20 pixels and 10 pixels, respectively. Use strictly morphological operations. The image is binary in nature.

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tever sate cett  
molecutes mait taser

[15M]

**Q6.** A 5×5 8-bit grayscale digital image in the form of a matrix ( $M$ ) is shown below. [3×5+5=20M]

55	95	208	101	115
45	98	121	126	121
121	124	135	33	146
111	156	109	202	132
127	112	122	109	180

- What is the response of a 3×3 median filter at  $M(4,3)$ ?
- What is the response of a 3×3 Max filter at  $M(3,4)$ ?
- What is the response of a 45° rotationally invariant Laplacian filter at  $M(3,3)$ ?
- Threshold the image  $M$  with the average grayscale value and write the final 5×5 thresholded image.
- What is the total number of white pixels in the above thresholded image?
- Extract the [least significant bit + 2]<sup>th</sup> plane and write the final result in form of a 5×5 matrix.