MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS
VI SEMESTER B. TECH (MECHATRONICS)
End Semester Assessment– 2023

Subject: Artificial Intelligence **Subject Code: MTE 4059**

Time: 180 Minutes **Exam Time:**

MAX. MARKS: 50

Instructions to Candidates:

- ***Answer ALL the questions.***
- *Missing data may be suitably assumed and justified.*

		M	CO	PO	LO	BL
1A	When gyros are calibrated for axis bias, they are matched with a temperature. Thus, we can have a relation of gyro bias (GB) vs. temperature (T). Suppose we have fuzzy sets for a given gyro bias and a given Fahrenheit temperature, as follows: $$\mu_{GB}(x) = \left\{\frac{0.2}{3} + \frac{0.4}{4} + \frac{1}{5} + \frac{0.4}{6} + \frac{0.2}{7}\right\}$$ bias in degrees Fahrenheit per hour $$\mu_{T}(y) = \left\{\frac{0.4}{66} + \frac{0.6}{68} + \frac{1}{70} + \frac{0.6}{72} + \frac{0.4}{74}\right\}$$ temperature in degrees Fahrenheit (a) Use a Mamdani implication to find the relation IF gyro bias, THEN temperature. (b) Suppose we are given a new gyro bias (GB) as follows: $$\mu_{GB'}(x) = \left\{\frac{0.6}{3} + \frac{1}{4} + \frac{0.6}{5}\right\}$$ Using max–min composition, find the temperature associated with this new bias	4	4	1	1	3
1B	Illustrate an algorithm mentioning the steps involved to train a neural network with RMSprop type of optimizer. Assume there are 'n' no. of training vectors with 'm' no. of input features, use of sigmoid activation function and squared error type of loss. $$v_t = \beta v_{t-1} + (1-\beta)\,(\nabla w_t)^2$$ $$w_{t+1} = w_t - \frac{\eta}{\sqrt{v_t + \epsilon}}\nabla w_t$$	4	2	1	1	3
1C	Identify methods that can be used to reduce a volume of 125×125×64 to a 125×125×32 volume in a convolutional neural network. 1 x 1 convolution, 32 filters	2	3	1	1	3
2A	Consider a fuzzy system with the following rules: If x is A and y is B then Z is A If x is B and y is A then Z is B	5	4	1	1	3

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Where A and B are fuzzy sets with membership functions:

$$\mu_A(x) = \begin{Bmatrix} 0 \;\; if\ x < 2 \\ \dfrac{x-2}{3} \quad if\ \ 2 \le x \le 5 \\ \dfrac{8-x}{3} \quad if\ 5 < x \le 8 \end{Bmatrix}$$

$$\mu_B(x) = \begin{Bmatrix} 0 \;\; if\ x < 1 \\ \dfrac{x-1}{2} \quad if\ \ 1 \le x \le 3 \\ \dfrac{5-x}{2} \quad if\ 3 < x \le 5 \end{Bmatrix}$$

Suppose that the input to the fuzzy system is (x*, y*) = (3,4) and we use the singleton fuzzifier,
Compute the output Z while using a Mamdani minimum inference engine with weighted average defuzzifier.
Formula:

$$\mu_{B'}(y) = \max_{l=1}^{M}[\sup_{\mathbf{x}\in U} min(\mu_{A'}(\mathbf{x}), \mu_{A_1^l}(x_1), ..., \mu_{A_n^l}(x_n), \mu_{B^l}(y))]$$
</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2B</td><td>
Three variables of interest in power transistors are the amount of current that can be switched, the voltage that can be switched, and the cost. The following membership functions for power transistors were developed from a hypothetical components catalog:

$$Average\ current\ (in\ amps) = \left\{\frac{0.4}{0.8} + \frac{0.7}{0.9} + \frac{1}{1} + \frac{0.8}{1.1} + \frac{0.6}{1.2}\right\}$$

$$Average\ voltage\ (in\ volts) = \left\{\frac{0.2}{30} + \frac{0.8}{45} + \frac{1}{60} + \frac{0.9}{75} + \frac{0.7}{90}\right\}$$

These two fuzzy sets are related to the ‘‘power’’ of the transistor. Power in electronics is defined by an algebraic operation, *P* = *V I*, but let us deal with a general Cartesian relationship between voltage and current, i.e., simply with P = V × I.

(a) Find the fuzzy Cartesian product P = V × I

Now let us define a fuzzy set for the cost C, in dollars, of a transistor, e.g.,

$$C = \left\{\frac{0.4}{0.5} + \frac{1}{0.6} + \frac{0.5}{0.7}\right\}$$

(b) Using a fuzzy Cartesian product, find T= I×C.
(c) Using max–min composition, find E = P ◦T.

Cartesian product P = V x I

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<tr><td></td><td>I</td><td>0.8</td><td>0.9</td><td>1</td><td>1.1</td><td>1.2</td></tr>
<tr><td>V</td><td>30</td><td>0.2</td><td>0.2</td><td>0.2</td><td>0.2</td><td>0.2</td></tr>
<tr><td></td><td>45</td><td>0.4</td><td>0.7</td><td>0.8</td><td>0.8</td><td>0.6</td></tr>
<tr><td></td><td>60</td><td>0.4</td><td>0.7</td><td>1</td><td>0.8</td><td>0.6</td></tr>
<tr><td></td><td>75</td><td>0.4</td><td>0.7</td><td>0.9</td><td>0.8</td><td>0.6</td></tr>
<tr><td></td><td>90</td><td>0.4</td><td>0.7</td><td>0.7</td><td>0.7</td><td>0.6</td></tr>
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</td><td>3</td><td>4</td><td>1</td><td>1</td><td>3</td></tr>
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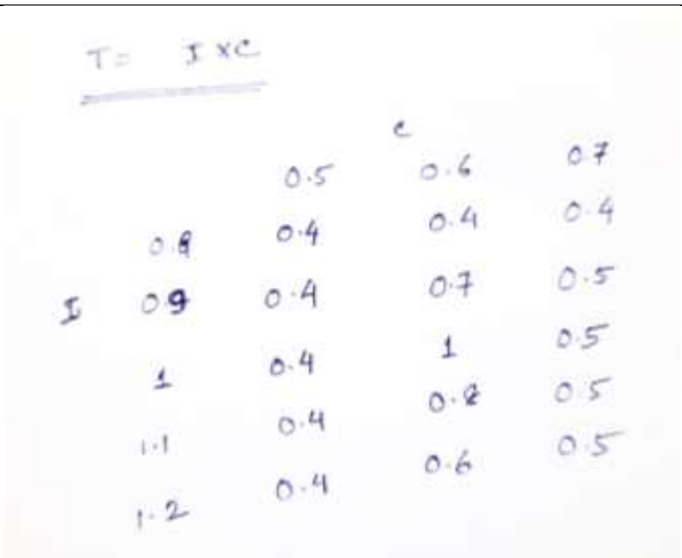
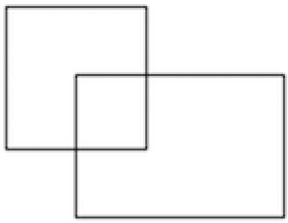
<tr><td></td><td>
</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2C</td><td>Calculate the IoU between the two boxes. The upper-left box is 2x2, and the lower-right box is 2x3. The overlapping region is 1x1..


1/9
Fig.2C</td><td>2</td><td>3</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>3A</td><td>Consider a fuzzy system with the following rules:
If x is A and y is B then Z is C1
If x is B and y is A then Z is C2

Where A and B are fuzzy sets with membership functions:

$$\mu_A(x) = \begin{cases} 0 & if\ x < 2 \\ \frac{x-2}{3} & if\ 2 \le x \le 5 \\ \frac{8-x}{3} & if\ 5 < x \le 8 \end{cases}$$
$$\mu_B(x) = \begin{cases} 0 & if\ x < 1 \\ \frac{x-1}{2} & if\ 1 \le x \le 3 \\ \frac{5-x}{2} & if\ 3 < x \le 5 \end{cases}$$
$$\mu_{C1}(x) = \begin{cases} 0 & if\ x < 3 \\ \frac{x-3}{2} & if\ 3 \le x \le 5 \\ 1 & if\ x > 5 \end{cases}$$
$$\mu_{C2}(x) = \begin{cases} 1 & if\ x < 3 \\ 4-x & if\ 3 \le x \le 4 \\ 0 & if\ x > 4 \end{cases}$$</td><td>5</td><td>4</td><td>1</td><td>1</td><td>3</td></tr>
</table>

	Suppose that the input to the fuzzy system is (x*, y*) = (3,4) and we use the singleton fuzzifier, Compute the output Z while using a Tsukamoto Fuzzy inference engine with weighted average defuzzifier					
3B	Let U and V be universe of discourse and A and B are fuzzy sets in U and V. A fuzzy If-Then rule is formed as: x is A’ If x is A then y is B Use generalized Modes Ponens to arrive a conclusion in the form y is B’, where, A→B is interpreted using Mamdani Minimum implication. For t norm and s norm operations, use basic minimum and maximum operators, respectively. $U = \{x_1, x_2, x_3\}$ V= $\{y_1, y_2\}$ $A = \left\{\frac{0.5}{x_1} + \frac{1}{x_2} + \frac{0.6}{x_3}\right\}$ $B = \left\{\frac{1}{y_1} + \frac{0.4}{y_2}\right\}$ $A' = \left\{\frac{0.6}{x_1} + \frac{0.9}{x_2} + \frac{0.7}{x_3}\right\}$ Step 1: $A \to B$ with Mamdani product implication $= \mu_{A \to B}(x,y)$ $\begin{array}{c\|cc} & y_1 & y_2 \\ x_1 & 0.5 & 0.2 \\ x_2 & 1 & 0.4 \\ x_3 & 0.6 & 0.24 \end{array}$ Step 2: Cylindrical extension of A' $c(A') = \mu_{A'}(x,y) =$ $\begin{array}{c\|cc} & y_1 & y_2 \\ x_1 & 0.6 & 0.6 \\ x_2 & 0.9 & 0.9 \\ x_3 & 0.7 & 0.7 \end{array}$ Step 3: Intersection of $c(A')$ and $A \to B$ $\mu_{A' \cap B}(x,y) =$ $\begin{array}{c\|cc} & y_1 & y_2 \\ x_1 & 0.5 & 0.2 \\ x_2 & 0.9 & 0.4 \\ x_3 & 0.6 & 0.24 \end{array}$ Step 4: Projection of $\mu_{A' \cap B}(x,y)$ on y $B' = \frac{0.9}{y_1} + \frac{0.4}{y_2}$	3	4	1	1	3
3C	Given two fuzzy sets A and B in universe of discourse X and Y, determine the fuzzy relation with minimum operator. $A = \left\{\frac{0.3}{1} + \frac{0.5}{2} + \frac{0.8}{3}\right\}$ $B = \left\{\frac{0.8}{1} + \frac{0.4}{2}\right\}$	2	4	1	1	3
4A	Answer the following questions with respect to object classification/ detection using convolutional neural networks:	4	3	2	2	4

	(a) Suppose you are working on image classification application, where you have to classify images as car, bike, cycle, tree, pedestrian, dog and cow. You have collected the data and want the classification to happen with your dataset. However, you do not have the required computation facility to train the network on multiple big images neither do you have adequate number of images for good accuracy. Analyze what can you do in such a scenario. (b) Identify and explain what can be done to detect overlapping objects while using certain CNN based algorithm, as shown below:  (c) While using a sliding window based technique for object detection, three bounding boxes predicted the location of a car. Analyze what method can be used to get the best one bounding box for localization.  Fig. 4A					
4B	Explain how YOLO algorithm reduces computation time when compared to a sliding window-based method for object detection	4	3	1	1	2
4C	Refer to the figure on which an object detection algorithm has been run: suppose you run non-max suppression on the predicted boxes below. The parameters you use for non-max suppression are that boxes with probability ≤0.4 are discarded, and the IoU threshold for deciding if two boxes overlap is 0.5. Identify how many boxes will remain after non-max suppression?	2	3	2	2	4

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Fig.4C
4</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5A</td><td>Discuss the value and role of privacy in information society.</td><td>4</td><td>5</td><td>8</td><td>8</td><td>2</td></tr>
<tr><td>5B</td><td>The set of input training vectors to a perceptron is as follows:
$$X_1 = \begin{bmatrix} 1 \\ -2 \end{bmatrix} \quad X_2 = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$
The initial weight vector W1 is assumed to be:
$$W_1 = \begin{bmatrix} 2 \\ -1 \end{bmatrix}$$
The learning constant is assumed to be 0.1. The desired response for X1 is d1= -1, d2= -1 respectively. Update the weights twice according to perceptron learning algorithm, using the signum activation function</td><td>3</td><td>1</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>5C</td><td>Consider a scenario in which an autonomous vehicle comes across a situation of an unavoidable collision. The collision cannot be avoided but necessary action can be taken to minimize damage. Two cyclists (one of them wearing a helmet) are crossing a certain road and the autonomous vehicle is moving in a direction which is orthogonal to the cycle direction. The vehicle doesn’t have the time to avoid the collision but has the time to take an action to decide with whom to collide. Refer to the picture below, considering all the ethical aspects, identify and justify how should the vehicle decide to act in this situation.

Fig. 5C</td><td>3</td><td>5</td><td>8</td><td>8</td><td>4</td></tr>
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