Roll No											

PRESIDENCY UNIVERSITY
BENGALURU

SET A

SCHOOL OF ENGINEERING
END TERM EXAMINATION - JAN 2024

Semester : Semester V - 2021

Course Code : ECE3030

Course Name : Fuzzy Logic and Its Engineering Applications

Program : B.Tech.

Date : 09-JAN-2024

Time : 9:30AM - 12:30 PM

Max Marks : 100

Weightage : 50%

Instructions:

(i) Read all questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and non-programmable calculator are permitted.
(iv) Do not write any information on the question paper other than Roll Number.

PART A

ANSWER ALL THE QUESTIONS **5 X 2M = 10M**

1. When considering the use of Fuzzy logic for a given problem, an engineer or scientist should consider the imprecision and uncertainty to solve the problem. Name the two different types of uncertainty in the situations (a) “The tossing of the dice will result in 5” and (b) “It is a rainy day”, and compare the two.

(CO1) [Knowledge]

2. Fuzzy relations are used in design of fuzzy systems. Let the Relational Matrix R is given as

$$\begin{bmatrix} .1 & .3 & .5 \\ .1 & .5 & .1 \\ .3 & .9 & .5 \end{bmatrix}$$

Find Domain and Height of R

(CO2) [Knowledge]

3. In many cases, the number c of clusters in the data is known. In other cases, c may take more than one value. In this situation it is necessary to identify the value of c that gives the number of clusters in the data for the analysis at hand. This problem is known as _____

(CO3) [Knowledge]

4. Suppose we have five data points in a universe, $X = \{x_1, x_2, x_3, x_4, x_5\}$. Also, suppose we want to cluster these five points into two classes. Find the cardinality of this hard c-partition for c=2

(CO3) [Knowledge]

5. Control systems are some times divided into two classes. Mention these control systems with examples.

(CO4) [Knowledge]

PART B

ANSWER ALL THE QUESTIONS **5 X 10M = 50M**

6. Fuzzy set operations and properties are helpful in simplification of system design. Fuzzy sets A and B are defined over the Universe of discourse

$X = \{1,2,3,4,5,6,7,8,9,10\}$.

Membership functions are given by $\mu_a(x) = \frac{x}{x+2}$ and $\mu_b(x) = 2^{-x}$

Find (i) $\bar{A} \cup \bar{B}$ (ii) $A \cup \bar{B}$ (iii) Prove DeMorgan's Theorems for the above fuzzy sets.

(CO1) [Comprehension]

7. Fuzzy rule base is used in fuzzy inference mechanism. Let X = { 1, 2, 3, 4 }; Y = { a, b, c, d } and the fuzzy sets

A = {(1, .2), (2, 1), (3, .8), (4, 0)}; B = {(1,0), (2, .4), (3, 1), (4,.8)}; and C = {(a, 0), (b, .8), (c, .6), (d, 1)}. Determine the implication relation using Zadeh's implication technique

i) IF x is A THEN y is C; ii) IF x is A THEN y is B ELSE y is C; iii) IF x is A and B THEN y is B ELSE y is C

(CO2) [Comprehension]

8. In a public transportation system there often is a significant need for speed control. For subway sytems, for example, the train speed can not go too far beyond a certain target speed or the trains will have trouble stopping at a desired location in the station. Set up a fuzzy set

$A = speed\ way\ over\ target = \left\{\frac{0}{T_0} + \frac{0.6}{T_0+5} + \frac{0.9}{T_0+10} + \frac{1}{T_0+15}\right\}$

on a universe of target speeds, $[T_0, T_0 + 15]$, where T_0 is a lower bound on speed. Define another fuzzy set $B = apply\ brakes\ with\ high\ force = \left\{\frac{0.3}{10} + \frac{0.8}{20} + \frac{0.9}{30} + \frac{1}{40}\right\}$ on a universe of Braking pressure, say S = [10, 40].

1. For the compound proposition, IF *speed is way over target*, THEN *apply brakes with high force*, find a fuzzy relation using classical (Zadeh's) implication.
2. For a new antecedent,

$A' = speed\ moderately\ over\ target = \left\{\frac{0.2}{T_0} + \frac{0.6}{T_0+5} + \frac{1}{T_0+10} + \frac{0.3}{T_0+15}\right\}$

Find the fuzzy brake pressure using max-min composition.

(CO2) [Comprehension]

9. Three families exists, which have a total of 8 people, all of whom are related with some similarity measure. A person not familiar with the members of the three families is asked to grade their resemblance to one another. In conducting this study, the person assigns the similarity level in the equivalence relation matrix R as shown below. Classify the three families using R according to λ-cut levels = 0.4, 0.6

$$R = \begin{bmatrix} 1.0 & 0.4 & 0.4 & 0.5 & 0.4 & 0.6 & 0.4 & 0.6 \\ 0.4 & 1.0 & 0.4 & 0.4 & 0.8 & 0.4 & 0.8 & 0.4 \\ 0.4 & 0.4 & 1.0 & 0.4 & 0.4 & 0.4 & 0.4 & 0.4 \\ 0.5 & 0.4 & 0.4 & 1.0 & 0.4 & 0.5 & 0.4 & 0.5 \\ 0.4 & 0.8 & 0.4 & 0.4 & 1.0 & 0.4 & 0.8 & 0.4 \\ 0.6 & 0.4 & 0.4 & 0.5 & 0.4 & 1.0 & 0.4 & 0.8 \\ 0.4 & 0.8 & 0.4 & 0.4 & 0.8 & 0.4 & 1.0 & 0.4 \\ 0.6 & 0.4 & 0.4 & 0.5 & 0.4 & 0.8 & 04 & 1.0 \end{bmatrix}$$

(CO3) [Comprehension]

10. There is a set procedure for obtaining the control surface, from approximations based on a collection of fuzzy IF – THEN rules that describes the dynamics of the controller. Illustrate this statement by describing the steps in designing a simple fuzzy control system with necessary block diagram.

(CO4) [Comprehension]

PART C

ANSWER ALL THE QUESTIONS **2 X 20M = 40M**

11. An IC manufacturing plant has decided to classify five machines into two classes: good investment and bad investment.
The data points in our sample, $X = \{x_1, x_2, x_3, x_4, x_5\}$,
are $x_1 = \{5, 20\}; x_2 = \{3.5, 35\}; x_3 = \{4, 25\}; x_4 = \{7, 10\}; x_5 = \{8, 22\}$.
Apply Fuzzy c Means (FCM) algorithm to determine fuzzy 2-partition after two iterations, $U^{(2)}$. Use weighting parameter $m' = 2$ and criterion for convergence, $\varepsilon_L \leq 0.01$.

Start with the initial 2-partition

$$U^{(0)} = \begin{bmatrix} 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 \end{bmatrix}$$

(CO3) [Application]

12. Most control systems are more complex than we can deal with, mathematically. In this situation, fuzzy control can be developed, provided a knowledge base about the control process exists and formed into a number of fuzzy rules. Design a fuzzy logic Air conditioner controller to turn the dial Z to control the flow of warm/hot or cool/cold air based on change in room temperature, ΔT°C, and the rate of change of temperature $\frac{\mathrm{d}}{\mathrm{d}t}\Delta T$. Consider ΔT = 3°C and $\frac{\mathrm{d}}{\mathrm{d}t}\Delta T = -2°C/min$. Assume appropriate membership functions and fuzzy rules in the design.

(CO4) [Application]