M. TECH. (COMPUTER TECHNOLOGY) 2ND YEAR 2ND SEMESTER EXAMINATION 2024

Computational Intelligence

Time: 3 Hours Full Marks: 100

Answer any ***four*** questions. *Different parts of the same question must be answered* ***together****. If answered* ***more than*** *4 questions, first 4 questions will be* ***evaluated****.*

1. a) Find the Cartesian product and intersection of the following fuzzy sets:
   $A = \{(3, 0.5), (5, 1), (7, 0.6), (9, 0.3)\}$
   $B = \{(2, 0.5), (3, 1), (5, 0.6)$ 5+5

   b) Define the general form of extension principle. 5

   c) Let A and B be fuzzy sets defined on the universal set X as follows:
   $A = \{(1, 0.6), (2, 0.8), (3, 1), (4, 0.6)\}$
   $B = \{(0, 0.5), (1, 0.7), (2, 0.9), (3, 1), (4, 0.4)\}$
   Let a function $f: X \times X \rightarrow X$ be defined by $f(x, y) = (x+y)$, $x \in A$, $y \in B$. Determine the image $f(A \times B)$ by the extension principle. 10

2. a) Define a linguistic variable with an example. 5

   b) What is linguistic hedge? Discuss different types of linguistic hedges with examples. 10

   c) Construct suitable membership functions (MF) of the linguistic terms '*young*' and '*old*'. Determine the membership functions of the terms '*very young*', '*not very old*' and '*more or less old*'. 10

3. Let the three fuzzy sets are defined as follows:

   $A = \{(x_1, 0.2), (x_2, 0\ 4), (x_3, 0.6), (x_4, 0.8)\}$, $B = \{(y_1, 0.5), (y_2, 0.3), (y_3, 0.2), (y_4, 0.1)\}$ and $C = \{(z_1, 0.5), (z_2, 1), (z_3, 0.6), (z_4, 0.3)\}$

   Now, (i) define the relation *R1* between A and B. (ii) Find the 1st and 2nd projection of *R1*. (iii) Compose the relations *R1* and *R2* (*R2* is the relation between B and C) by using the *max-min composition.* 5+(2+3)+(5+10)

4. a) Describe the fuzzy c-means (FCM) clustering algorithm and derive its iterative equations for finding cluster centres and membership function. 10

   b) Consider the following fuzzy if-then rule:

   (i) If x is A and y is B then z is C

   where $A \in \boldsymbol{X}$, $B \in \boldsymbol{Y}$ and $C \in \boldsymbol{Z}$ are fuzzy sets as follows:

   $A = 1/x_1 + 0.7/x_2 + 0.3/x_3$
   $B = 0.9/y_1 + 0.5/y_2 + 0.3/y_3$

$C = 0.2/z_1 + 0.9/z_2 + 0.6/z_3 + 0.4/z_4$

Given the fact:

x is A' and y is B'

where $A' = 0.8/x_1 + 0.9/x_2 + 0.2/x_3$ and $B' = 0.7/y_1 + 0.6/y_2 + 0.2/y_3$

Use the composition rule of inference to calculate the conclusion C' 15

5. a) Let there are N training samples, each one has p features from C classes. Design a multilayer perceptron (MLP) with K hidden layer neurons. Write the back-propagation algorithm to train the MLP. 5+10

   b) State the functions of an RBF neural network. Write a training procedure of an RBF neural network with K hidden layer neurons and C output layer neurons using N training samples of p dimension. 10

6. a) Describe a computationally efficient method for finding the optimal hyperplane of a SVM. 15

   b) Describe the pattern classification procedure in a k-nearest neighbor classifier. 10