Ref. No. : EX/PG/CSE/PE/T/114A/2025

M.E. COMPUTER SCIENCE & ENGINEERING 1st YEAR 1st SEMESTER EXAMINATION 2025

APPLIED SOFT COMPUTING

Full Marks: 100

Answer any Five Questions

Answer all the parts of a Question together

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1. a) What is "Soft Computing"? Is there any relation between Artificial Intelligence and Soft Computing? – Discuss. (3+3)

   b) What are the major computing methodologies used in Soft Computing? State the function of each of these methods. Besides these, name the other techniques used. (6)

   c) Justify (T/F: with reasoning/ examples): "Finding out the exact (fully correct) solution is not always necessary and also not reasonable". (4)

   d) Justify (T/F: with reasoning/ examples): The applicability of Soft Computing is widespread in the areas of Pattern Recognition and Image Processing. (4)

2. a) What features of an Artificial Neural Network make it a suitable tool for "Learning"? (4)

   b) What is a "Perceptron"? Justify: (T/F: with reasoning/ examples): "A Perceptron can always generate a decision boundary between patterns of two classes". (3+4)

   c) Design a two input "AND" function using Perceptron. (5)

   d) Justify: (T/F: with reasoning/ examples):-

   Consider two datasets D(1) and D(2) where $D(1) = \{(x^{(1)}1 , y^{(1)}1), ..., (x^{(1)}n , y^{(1)}n)\}$ and $D(2) = \{(x^{(2)}1 , y^{(2)}1), ..., (x^{(2)}m , y^{(2)}m)\}$ such that $x^{(1)}i \in \mathbb{R}^{d1}$, $x^{(2)}i \in \mathbb{R}^{d2}$. Suppose $d1 > d2$ and $n > m$. Then the maximum number of mistakes a perceptron algorithm will make is higher on dataset D(1) than on dataset D(2). (4)

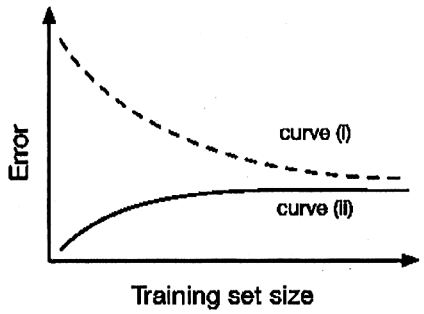
3. a) Consider a Multi-Layer Perceptron (MLP) model with two hidden layers and one output layer. The first hidden layer has 12 neurons, the second has 8 neurons, and the output layer has 4 neurons. The input to the MLP is a 5-dimensional vector. Each neuron is connected to every neuron in the previous layer, and a bias term is included in each neuron. The activation function used is the Sigmoid function. Calculate the total number of trainable parameters in this MLP model. (2)

b) What is the significance of "hidden" neurons in Artificial Neural Network? Discuss the significance of the term "backpropagation" while MLP learns. (2+4)

c) Assume we have a set of data from patients who have visited a hospital. A set of features (e.g., temperature, height) have been extracted for each patient. Our goal is to decide whether a new visiting patient has any of diabetes, heart disease, or Alzheimer (a patient can have one or more of these diseases).

We have decided to use a neural network to solve this problem. We have two choices: either to train a separate neural network for each of the diseases or, to train a single neural network with one output neuron for each disease, but with a shared hidden layer. Which method do you prefer? Justify your answer. (4)

d) In the following figure, which curve represents the training error? What does the gap between the two curves at the end represent? Explain your answer. (4)



e) Is it true that any multi-layered neural net with linear activation functions at hidden layers can be represented as a neural net without any hidden layer? Briefly explain your answer. (4)

4. a) Describe in detail the differences between Multi-Layer Perceptron (MLP) and Radial Basis Function (RBF) Networks (mention the parameters for comparison). (4)

b) Consider Kohonen Net with two cluster units & three input units. The weight vector for the cluster units are (0.9,0.7,0.6) and (0.4,0.3,0.5). Find the winning cluster unit for the input vector (0.4,0.2,0.1) using learning rate of 0.2. Find new weights for the winning unit. (4)

c) Describe in detail the differences between Kohonen Network and Hopfield model of Neural Network (mention the parameters for comparison). (4)

d) A 32×32 grayscale image is passed through a convolutional layer with 8 filters of size 5×5, using a stride of 1 and no padding. What will be the spatial dimensions of the output feature map? (3)

e) Why do CNNs use pooling layers, and how does max pooling work? (3+2)

5. a) Define Fuzzy set. Draw the differences between the Fuzzy set and the Crisp set. (2+5)

b) Consider the fuzzy sets A and B defined in the interval X = [1,10] of real numbers by the membership grade functions:

$\mu_A(x) = 2x/(2x+1)$ and $\mu_B(x) = 3^{-x}$

Determine the mathematical formula and the graphs of the membership grade functions for: $A \cap B$. (5)

c) When is a fuzzy set said to be "sub-normal"? How can you make it "normal"? (4)

d) Draw the fuzzy membership function for "old". From this, draw "not very old". (4)

6. a) Describe the four frequently used S-norm operator. (4)

b) Consider the following two fuzzy sets:

$X = 0.1/0 + 0.2/1 + 0.3/2 + 0.4/3 + 0.5/4$ and

$Y = 0.5/0 + 0.4/1 + 0.3/2 + 0.2/3 + 0.1/4$

Perform (i) Algebraic Product (ii) Algebraic Sum and (iii) Drastic Sum over these two fuzzy sets. (6)

c) In Communication there is an imprecise relationship between the level of use of a network communication bandwidth and the latency experienced in a peer-to-peer communication system. Let X be a fuzzy set of used levels (in terms of % of full bandwidth used) and Y be a fuzzy set of latencies with the following membership functions.

$X = \{0.3/10 + 0.6/20 + 0.9/40 + 1.0/60 + 0.6/80 + 0.3/100\}$

$Y = \{0.2/0.5 + 0.5/1 + 0.8/1.5 + 1.0/4 + 0.06/8 + 0.1/20\}$

Find the Cartesian product represented by a relation $R = X \times Y$.

Now suppose we have a second fuzzy set of bandwidth usage as follows:

$Z = \{0.4/10 + 0.7/20 + 0.8/40 + 0.9/60 + 1/80 + 0.5/100\}$

Find $S = Z_{1x6} . R_{6x6}$ using max-min composition. (4+6)

7. a) Discuss the utilities of crossover and mutation operators in Genetic Algorithm (GA). (4)

b) Consider the following four chromosomes present in a population at any time t (population size=4). Probability of crossover is 0.8 and the probability of mutation is 0.02.

Chromosome 1: 10001011
Chromosome 2: 11110001
Chromosome 3: 10101010
Chromosome 4: 10000000

Can a GA find out 01000100 if there is no mutation? Give reasons in support of your answer. (2)

c) Derive Schema Theorem. (5)

d) Why do we need to introduce new crossover operator for solving TSP using GAs? (3)

e) How do you view a chromosome in each of the cases? (3+3)
   i) k-medoid clustering algorithm using GA.
   ii) Image enhancement using GA.

8. Answer any **five** questions from the following:

a) Why do RNNs suffer from the vanishing gradient problem? (4)

b) What is the function of the "forget" gate in LSTM ? (4)

c) What is the usefulness of "positional encoding" in Transformers? (4)

d) Is there any difference between "Neuro-Fuzzy" and "Fuzzy-Neuro" approaches? Discuss. (4)

e) Briefly describe on "defuzzification" approaches. (4)

f) What are the "global best" and "local best" particles in PSO? (4)

g) How does the "pheromone evaporation rate" affect the performance of ACO algorithm?(4)

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