Ref. No. : EX/PG/CSE/T/128C/2024

M.E. COMPUTER SCIENCE & ENGINEERING 1st YEAR 2nd SEMESTER EXAMINATION 2024

SOFT COMPUTING

Full Marks: 100

Answer any Five Questions

1. a) What is "Soft Computing"? What is the aim of Soft Computing? How does it differ from traditional "Hard Computing"? (3+3+4)

   b) What characteristics might a machine possess to achieve "human-like behaviour"? (4)

   c) Justify: "The methodologies comprising Soft Computing are for the most part complementary and synergistic, rather than competitive". (6)

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

   b) What is a "Perceptron"? Justify: "A Perceptron can generate a decision boundary between two classes of patterns". (2+4)

   c) How does a Perceptron model the "AND" function? (5)

   d) Describe the Delta rule of Learning for Single-layer Perceptron. (5)

3. a) Why do we go for Multilayer neural networks instead of Single-layered nets? (4)

   b) Consider a Multi-Layer Perceptron (MLP) model with one hidden layer and one output layer. The hidden layer has 10 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. (3)

   c) Discuss the significance of the term "backpropagation" while learning through MLP.

   Suppose you use the following architecture to design an MLP for classification. It has a single hidden layer with the hard threshold activation function. The output layer uses the softmax activation function with cross-entropy loss. What will go wrong if you try to train this network using gradient descent? Justify your answer in terms of the backpropagation rules. (3+4)

   [Consider: Softmax function converts a vector of raw prediction scores into probabilities; Cross-entropy loss measures the performance of a classification model whose output is a probability value between 0 and 1. This loss value increases as the predicted probability diverges from the true label.]

d) How does performance of an MLP vary with the variation of the following factors? (6)

i) Percentage of training data

ii) Percentage of test data

iii) Learning rate

iv) Number of hidden layers

4. a) Describe in detail the similarities and differences between Multi-Layer Perceptron (MLP) and Radial Basis Function (RBF) Networks. Briefly describe one of the applications of the RBF Network. (6+4)

b) Write down the working principle of the Hopfield model of Neural Networks. Briefly describe one of its applications. (5+5)

5. a) What do you understand by the term "Self-organization"? (2)

b) Discuss the architecture of Kohonen's Self-organizing Feature Map Neural Network. In Kohonen's Network, how do you obtain the "winning neuron" (best matching unit)? (4+4)

c) How are the weight values changed in Kohonen's network? Explain the significance of each of the factors responsible for weight change. (6)

d) In which kind of applications this network is more suitable? (4)

6. a) What is a fuzzy set? Draw the differences between the fuzzy set and the crisp set. (3+5)

b) Let X = [1,10], A = small integers, B = integers close to 4. Find A $\cap$ B. (4)

c) The membership function distribution of a fuzzy set is assumed to follow a Gaussian distribution with mean (μ) = 100 and standard deviation (σ) = 20. Determine 0.6 cut of this distribution. (4)

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

7. a) In the Genetic Algorithm (GA), crossover is treated as the primary operator and mutation as the secondary one" - Why? (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 0.002.

Chromosome 1: 10001011
Chromosome 2: 11110001
Chromosome 3: 10101010
Chromosome 4: 00000000

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

c) Derive Schema Theorem. (6)

d) How do you view a chromosome while solving 0/1 Knapsack Problem using GAs? (3)

e) How can you perform crossover and mutation operations for working with the k-medoid clustering algorithm using GA? (5)

8. a) Consider a universe of aircraft speed near the speed of sound as X = {0.72, 0.725, 0.75, 0.775, 0.78} and a fuzzy set on this universe for the speed "near match 0.75" = M where

M = {(0/0.72) + (0.8/0.725) + (1/0.75) + (0.8/0.775) + (0/0.78)}

Define a universe of altitudes as Y = {21, 22, 23, 24, 25, 26, 27} in k-feet and a fuzzy set on this universe for the altitude fuzzy set "approximately 24000 feet" = N where

N = {(0/21k) + (0.2/22k) + (0.7/23k) + (1/24k) + (0.7/25k) + (0.2/26k) + (0/27k)}

(i) Construct a relation R = M x N

(ii) For another aircraft speed, say, M1, in the region of match = 0.75 where

M1 = {(0/0.72) + (0.8/0.725) + (1/0.75) + (0.6/0.775) + (0/.78)}

Find relation S = M1 o R using max-min composition. (8)

b) Discuss on the encoding of solution, fitness function, and genetic operators used for solving GA for the Travelling Salesman Problem. (6)

c) Design a layered neural network for generating a non-convex decision region. (6)

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