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[This question paper contains 2 printed pages]

Unique Paper Code : 2514000016

Name of the Paper : Neural Networks

Name of the Course : B.Sc. (H) Electronics (GE)

Semester : VII (Under NEP UGCF Mode)

Duration : 3 Hours

Maximum Marks : 90

Instruction for Candidates

1. There are seven questions in all, out of which you have to attempt any five questions.
2. All questions carry equal marks.
3. Use of non-programmable Scientific Calculator is allowed.
4. First Question is Compulsory.

1.	a.	What is an activation function? Mention any two commonly used activation functions.	3
	b.	Write limitations of a single-layer perceptron.	3
	c.	Differentiate between a crisp set and a fuzzy set.	3
	d.	What is the significance of the Learning Curve in algorithms like LMS or Back Propagation?	3
	e.	Briefly explain the concept of Unconstrained Organization Techniques in learning.	3
	f.	Explain the three main genetic operators—Selection, Crossover, and Mutation.	3
2.	a.	Explain how fuzzy logic differs from conventional logic. Discuss its role in handling uncertainty in AI systems.	6
	b.	Explain the structure and function of an artificial neuron. How do weights and activation functions contribute to learning?	6
	c.	For a perceptron model with initial weights w=[0.2,0.4], bias = 0.1, learning rate = 0.5, and desired output = 1 for input x=[1,1], perform one iteration of weight update.	6
3.	a.	Differentiate between supervised, unsupervised, and reinforcement learning paradigms with examples of each in real-world AI applications.	6
	b.	Derive the mathematical model of a neuron and explain how input summation and activation function together determine output.	6
	c.	A neuron uses the activation function $f(v)=1/(1+e^{-v})$. For inputs x=[0.6,−0.8], weights w=[0.3,0.5], and bias = 0.1, compute the output.	6

4. a. State the Perceptron Convergence theorem and describe the necessary condition on the training data for convergence to be guaranteed. Illustrate graphically why this condition is vital for the single-layer perceptron. 6

   b. Explain why the XOR (Exclusive OR) problem is non-linearly separable, preventing a single-layer perceptron from solving it. Describe, conceptually, how the introduction of a hidden layer and non-linear activation functions in a Multi-Layer Perceptron (MLP) enables the network to solve the XOR problem. 6

   c. A single-layer perceptron has three inputs $x_1=0.5$, $x_2=1.0$, and $x_3=-0.5$. The corresponding weights are $w_1=0.2$, $w_2=-0.4$, and $w_3=0.6$. The bias is $b=0.1$. If the activation function is a binary step function where the output is 1 if the net input is ≥ 0 and 0 otherwise, calculate the net input V and the final output y. 6

5. a. Describe the role of the Least Mean Square (LMS) algorithm in solving an Adaptive Filtering Problem. What are the key components of a typical adaptive filter structure (e.g., input, weights, error calculation)? 6

   b. Explain the architecture and primary application of a Recurrent Neural Network (RNN). Why are RNNs essential for tasks involving sequences? 6

   c. Consider two fuzzy sets, 'Young' (Y) and 'Middle Aged' (M), defined over the universe of ages {20, 30, 40, 50, 60}: 6
   text{Young} (Y) = { 0.9/20, 0.7/30, 0.3/40, 0.1/50, 0.0/60 }
   text{Middle Aged} (M) = { 0.0/20, 0.4/30, 0.8/40, 1.0/50, 0.6/60}
   Task:
      i. Calculate the fuzzy set 'NOT Young'
      ii. Calculate the fuzzy set 'Young OR Middle Aged'
      iii. Calculate the fuzzy set 'Young AND Middle Age'

6. a. Derive the delta learning rule for a single neuron and explain how it minimizes the error using gradient descent. 6

   b. Explain how supervised, unsupervised, and reinforcement learning paradigms differ in data requirement and feedback mechanism. 6

   c. A single-layer perceptron has inputs $X_1=1$, $X_2=-1$, weights w1=0.5, w2=0.3, bias = 0.2, and uses a step activation function with threshold = 0. 6
   (a) Compute the output.
   (b) If the desired output is -1 and learning rate = 0.1, compute the new weights after one iteration.

7. a. Explain the need for and the mechanism of Simulated Annealing in a Boltzmann Machine. How does the introduction of 'temperature' (T) help the network overcome the problem of getting stuck in poor local minima of the energy landscape? 6

   b. Discuss the principles of Fuzzy Logic and its relevance to Neural Networks. Explain how the use of Fuzzy Sets and Membership can help a system deal with the problem of imprecise or uncertain solution data. 6

   c. A single neuron is trained using the LMS rule. The input is x=2, the current weight is w=0.5, and the desired output is d=6. The learning rate is $\eta=0.1$. 6
      i. Calculate the actual output, y
      ii. Calculate the error E.
      iii. Calculate the new weight w_{new} using the LMS update rule