Ex/PG/ETCE/T/115A/16/2017

M.E.T.C.E 1st Semester Examination 2017

Neuro-Fuzzy and Evolutionary Computation **Time: 3 hours** **Full Marks: 100**

Answer **Q.1 and any five** from the rest.

Q.1 a) Explain the problem of partial matching and clarify how fuzzy sets can tackle that problem.

b) Define a fuzzy membership function with an example.

c) Explain the possible projections of a binary fuzzy relation with a suitable example.

d) What is meant by a local fuzzy rule? Express the Mamdani implication relation for such a rule.

e) Discuss the importance of Cohen-Grossberg Theorem.

f) Realize a 2-input NAND function using McCulloch-Pitts neurons.

g) Argue why the gradient descent learning in the backpropagation algorithm is stochastic is nature. Hence, comment on the convergence of this algorithm.

h) What is Hebbian learning? How it is different from competitive learning?

i) How genetic algorithm is different from other optimization and search strategies?

j) Find the crossover survival probability of a schema H = * * 110 * *. Assume that the cross-over is performed with a probability 0.15.

10 x 3

Q.2 a) Show that the function *Einstein sum* $S_{es}(a,b) = (a+b)/(1+ab)$ is an S-norm.

b) Consider a fuzzy set A = $\{0.1/x_1, 0.5/x_2, 0.7/x_3, 0.9/x_4, 1.0/x_5, 0.5/x_6\}$. Compute cross-over (A) and $A_{0.7}$.

c) Define fuzzy max-min composition and mention its properties.

4 + (2+2) + (2+4)

Q.3 a) What is Generalized Modus Ponens? How it can be applied for drawing fuzzy inference?

b) Consider a system with two fuzzy production rules:

PR1: If height is TALL then speed is HIGH

PR2: If height is MEDIUM then speed is MODERATE

Given: $\mu_{TALL}(\text{height}) = [0.5/5', 0.8/6', 1.0/7']$, $\mu_{HIGH}(\text{speed}) = [0.6/6 \text{ m/s}, 0.8/8 \text{ m/s}, 0.5/9 \text{ m/s}]$, $\mu_{ABOVE\_AVERAGE}(\text{height}) = [0.5/5', 0.9/6', 0.8/7']$ and the fuzzy relational matrix R_2(height, speed) for PR2:

$$\begin{bmatrix} 0.6 & 0.9 & 0.7 \\ 0.5 & 0.8 & 0.6 \\ 0.8 & 0.7 & 0.5 \end{bmatrix}$$

Find $\mu_{ABOVE\_NORMAL}(\text{speed})$. Assume Mamdani implication for the construction of the fuzzy relational matrix R_1(height, speed) for PR1.

(3+3)+8

Q.4 a) Explain the basic principle of the Fuzzy C-Means (FCM) algorithm with suitable sketches.

b) Obtain the membership of the k^{th} data point (vector) to belong to the i^{th} cluster A_i for the above algorithm.

c) Discuss one important limitation of FCM with an example. Show the modified objective function of FCM which can take care of the above problem.

4+5+5

Q.5 a) Describe the basic components of an artificial neuron. Write two functions, one describing a hard and the other describing a soft non-linearity.

b) Explain the necessity of multiple layers in a neural network. Design a classification strategy for a Boolean function which can be only realized with multilayer perceptrons.

(3+2)+(3+6)

Q.6 a) Derive expressions for weight updates in the output and the penultimate layers of neurons in the back-propagation algorithm. Assume suitable functions for synaptic non-linearity.

b) From the expressions in a) can you justify the name of the algorithm as "backpropagation"?

c) Discuss the impact of learning rate on the performance of the algorithm in a).

d) Suggest a learning rate based strategy which can improve the convergence of the algorithm in a).

6+3+2+3

Q.7 a) Discuss the topology and the principle of a discrete Hopfield network.

b) Explain how competitive learning and network topology influence the working of Self Organizing Feature Map.

c) Consider a competitive learning algorithm with three successive training patterns: $i_1 = \{1.1, 1.7, 1.8\}$; $i_2 = \{0, 0, 0\}$; $i_3 = \{0, 0.5, 1.5\}$, three nodes A, B, C, and learning rate = 0.5. The initial connection strengths of the network with three input nodes and three output nodes are given by:

$$\begin{bmatrix} w_A & 0.2 & 0.7 & 0.3 \\ w_B & 0.1 & 0.1 & 0.9 \\ w_C & 1 & 1 & 1 \end{bmatrix}$$

Further assume that the network has a linear topology of the form: B – A – C. At each stage, the weights of the winner and its neighboring neurons should be updated. Show the updated weight matrix for three iterations.

4+4+6

Q.8 a) Explain the three standard stochastic operations in genetic algorithm.

b) Show following the Schema theorem, the sample size $m_H(t)$ of a schema H in generation t would grow exponentially in subsequent generations if its average fitness f_H is higher than the average fitness f_{av} of the population.

(2+2+2)+8