SOFT COMPUTING
(CSEN 5202)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Intersection of two fuzzy sets R and S means
(a) Max [μ_R (x), μ_S (x)] (b) Min [μ_R (x), μ_S (x)]
(c) μ_R (x) - μ_S (x) (d) μ_R (x) * μ_S (x)

(ii) Consider two given fuzzy sets A and B are:
A = { 1/ p + 0.3 /q + 0.5/r + 0.2/s}
B= { 0.5/ p + 0.4/q + 0.1/r + 1/s }
Then A∩B =
(a) {1/ p + 0.3 /q + 0.5/r + 0.2/s } (b) {0.5/ p + 0.3/q + 0.1/ r + 0.2/s }
(c) {1/ p + 0.4/q + 0.5/ r + 1/s } (d) {0.5/ p + 0.2/q + 0.1/ r + 1/s }.

(iii) A neuron with input [x1, x2, x3] = [0 · 3, 0 · 5, 0 · 6] and weights [w1, w2, w3] = [0 · 2, 0 ·1, – 0 · 3], the output of linear transformation in this neuron having bias=0.08 will be
(a) 0·07 (b)– 0·07 (c) 0·01 (d) – 0·01

(iv) What is the main advantage of using ReLU (Rectified Linear Unit) activation function compared to other activation functions like Sigmoid and Tanh?
(a) ReLU mitigates vanishing gradient problem
(b) ReLU guarantees a bounded output
(c) ReLU is differentiable at all points
(d) ReLU is always positive

(v) Genetic algorithm is a
(a) search technique used in computing to find true or approximate solution to optimization and search problem
(b) sorting technique used in computing to find true or approximate solution to optimization and sort problem
(c) both (a) & (b)
(d) none of these.

(vi) Which of the following activation function is most suitable for data classification problem, having more than two classes?
(a) Argmax (b) Sigmoid (c) RELU (d) Softmax.

(vii) Which type of optimization problem aims to simultaneously optimize multiple conflicting objectives?
(a) Single-Objective Optimization (b) Multi-Objective Optimization
(c) Binary Optimization (d) Continuous Optimization.

(viii) Which layer type is used to reduce the spatial dimensions in a CNN?
(a) Convolution layer (b) Pooling layer
(c) Fully connected layer (d) Activation layer.

(ix) A 4-input neuron has weights 1, 1, 2 and 2. The transfer function is linear with the constant of proportionality being equal to 1. The inputs are 4, 4, 5 and 5 respectively. The output will be
(a) 51 (b) 76 (c) 28 (d) 52

(x) What happens when the learning rate is low?
(a) It always reaches the minima quickly (b) It reaches the minima very slowly
(c) It overshoots the minima (d) Nothing happens.

Fill in the blanks with the correct word

(xi) The degree of membership of an object in a fuzzy lies in the range _____

(xii) In fuzzy set theory, the _____ function is used to define the degree of membership of elements in a fuzzy set.

(xiii) Logistic Function f(x)=_____.

(xiv) Convolutional Neural Networks (CNNs) are specialized for processing grid-like data such as images due to the presence of _____ layers.

(xv) The _____ function is commonly used as an activation function in the output layer of neural networks for binary classification tasks.

Group - B

2. (a) Two wheelers bikes of a vehicle company can be represented by the following fuzzy sets:
"Powerful Bike" = { 0.9/BikeA +0.4/ BikeB + 0.8/ BikeC + 0.2/ BikeD }
"Fast Pickup Bike"={0.5/ BikeA + 0.8/ BikeB + 0.6/ BikeC + 0.9/ BikeD}.
Estimate the following:
(i) Bounded Sum between the above two sets
(ii) Bounded Product between the the above two sets. *[(CO2)(CO4)(APPLY/LOCQ)]*

(b) Two fuzzy relations R and S are as following:

Relation S	Z1	Z2	Z3
1	0.9	0.5	0.3
Y2	0.8	0.4	0.7

Relation R	Y1	Y2
X1	0.6	0.3
X2	0.2	0.9

Find the Max-min Composition between R and S. *[(CO2,CO4)(APPLY/IOCQ)]*

(c) Explain briefly how fuzzy set is different from crisp set? *[(CO1)(UNDERSTAND/LOCQ)]*

(3 + 3) + 4 + 2 = 12

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

$$X= \frac{0.2}{10}+\frac{0.5}{20}+\frac{0.8}{40}+\frac{1.0}{60}+\frac{0.6}{80}+\frac{0.1}{100}$$

$$Y= \frac{0.3}{0.5}+\frac{0.6}{1}+\frac{0.9}{1.5}+\frac{1.0}{4}+\frac{0.6}{8}+\frac{0.3}{20}$$

Find the Cartesian Product represented by the relation R= X **x** Y

Now, suppose we have a second fuzzy set of bandwidth usage given by:

$$Z= \frac{0.3}{10}+\frac{0.6}{20}+\frac{0.7}{40}+\frac{0.9}{60}+\frac{1}{80}+\frac{0.5}{100}$$

Find S=Z **o** R

Using max-min composition

Using max-product composition. *[(CO2)(Analyse/IOCQ)]*

(b) A= {0.5/a, 0.8/b, 1/c, 0.9/d, 0.2/e}

B= {0.8/a, 0.2/b, 0.7/c, 0.6/d, 0.1/e}

Find for A and B independently:

(i) Support (ii) Core (iii) Cardinality. *[(CO2)(Analyse/IOCQ)]*

(2 × 3) + (2 × 3) = 12

Group - C

4. (a) Consider the following 1-dimensional points together with their class labels:

Class I: $x_1 = 1$, $x_2 = 0$ and $d^{(1)} = d^{(2)} = +1$;

Class II $x_3 = -1$, $x_4 = 1$ and $d^{(3)} = d^{(4)} = -1$.

Find the weight vector after four epochs using simple perceptron learning rule. Assume learning constant, $\eta = 1$, initial weight vector $w = [0.5,0.5]^T$ and bias =-1. Consider signum function as activation function. *[(CO5)(Analyse/IOCQ)]*

(b) Explain the concept of linear regression in machine learning. How does it differ from logistic regression? *[(CO4)(Remember/LOCQ)]*

(c) Describe the process of gradient descent in the context of optimizing the parameters of a linear regression model. *[(CO3)(Apply/LOCQ)]*

5 + (2 + 2) + 3 = 12

5. (a) Explain the significance of the cross-entropy loss function in the context of logistic regression. How is it formulated, and why is it preferred over other loss functions for classification tasks? *[(CO3)(Analyse/LOCQ)]*

(b) Suppose Input features space has four dimensions and we have a classification problem with four classes. Now it is also given that all the data set linearly separable. Suggest Neural Network architecture to classify this input dataset. *[(CO5)(Remember/LOCQ)]*

6 + 6 = 12

Group - D

6. (a) Use genetic algorithm to maximize the function f(x)=x2 for $0 \le x \le 31$. The four initial population chromosome's size of five is selected as 01101, 11000, 01000, 10011. Show details for first two iterations. *[(CO3)(Remember/IOCQ)]*

(b) What are the different types of crossover? *[(CO3)(Evaluate/LOCQ)]*

(c) Explain the roulette wheel algorithm. *[(CO3)(Apply/LOCQ)]*

6 + 2 + 4 = 12

7. (a) "In Genetic Algorithm, crossover is an exploitation oriented approach and mutation on exploration oriented approach to generate newer off-spring"- Do you agree or not agree with this statement. Explain your answer with proper justification. *[(CO3,CO4)(Analyse/HOCQ)]*

(b) What is permutation encoding in Genetic Algorithm? Explain any two crossover techniques suitable for permutation encoding in Genetic Algorithm, using suitable examples. *[(CO3,CO4)(UNDERSTAND/IOCQ)]*

(c) Briefly explain using suitable example that how Roulette wheel Selection techniques differ from Tournament based selection techniques in Genetic Algorithm. *[(CO3,CO4)UNDERSTAND/LOCQ)]*

3 + (1 + 4) + 4 = 12

Group - E

8. (a) Explain the purpose of using convolution Layer in a CNN based deep learning model in image classification.
Discuss how the filter size of a convolution layer is determined.
[(CO5,CO4,CO6)(UNDERSTAND/IOCQ)]

(b) Explain how soft-max function differs from arg-max function while performing max-pooling in CNN deep learning model. *[(CO5,CO4,CO6)(ANALYZE/IOCQ)]*

(c) What is the purpose of using max pooling in the CNN based deep learning model in image classification? *[(CO5,CO4,CO6)(UNDERSTAND/LOCQ)]*

(3 + 2) + 4 + 3 = 12

9. Discuss (**any two**) of the followings:

(i) Recurrent Neural Network *[(CO5,CO4,CO6)(UNDERSTAND/LOCQ)]*

(ii) Long short term memory (LSTM) network. *[(CO5,CO4,CO6)(UNDERSTAND/LOCQ)]*

(iii) Multi-objective optimization problem *[(CO5,CO6)(EVALUATE/LOCQ)]*

(6 + 6) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	54.17	42.71	3.13

Course Outcome (CO):

After the completion of the course students will be able to

CSEN5202.1 Learn (remember) and understand soft computing techniques and their roles in building intelligent machines.

CSEN5202.2 Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems.

CSEN5202.3 Design (create) methodology to solve optimization problems using genetic algorithms

CSEN5202.4 Analyze and evaluate solutions by various soft computing approaches for a given problem.

CSEN5202.5 Understand various models of artificial neural networks and their applications in solving pattern recognition and machine learning problems.

CSEN5202.6 Develop intelligent systems leveraging the paradigm of soft computing techniques.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*