National University of Computer and Emerging Sciences 0207

Artificial Intelligence (AI 2002) — Sessional-II Exam

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Total Time: 1 Hours

Total Marks: 30

Total Questions: 9

Semester: SP-2025

Campus: Lahore

Dept: Computer Science

Data Science

Maham Naeem ________ ________ ________

Student Name Roll No Section Student Signature

Me :) ________

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ATTEMPT ALL QUESTIONS AND WRITE YOUR ANSWERS IN THE SPACE PROVIDE

CLEARLY STATE ASSUMPTIONS IN CASE OF ANY MISSING INFORMATION

CLO 1 for questions 1,2,3:

CLO 2 for questions 4..9

[1] [8 Points] For each of the following problems suggest a suitable chromosome representation that might be used for searching an optimal solution using Genetic Algorithms (GA). Also suggest a method/way to compute fitness of the proposed chromosome.

a. We want to find maximum value of a function f (n) over integers in the range [0 2^{100}].

represent exponentiel in a 7 bits or 101 bits etc

fitness = max($2^{\text{chromose decimal}}$)

b. We want to maximize a function f(x, y) of two real valued variables each in the range (-100 100).

chromosome of 201 bit or x, y can be represent by binary bits with sign 8 bits for each

fitness = max f(x, y) posible more with more sign postive No of bits more etc.

c. We want to schedule midterm exams of NUCES-FAST

feature of chromosome be any time slots, bit days, Class Rooms, subject, No of class on each slot etc invigilator duties etc fitness => All subjet covert less clash free to not stu or with respect to invilator No more than two paper conduct in a class etc

d. We want to find optimal weights of a perceptron with 10 inputs.

Chromosome of 10 + 1 (w, b) 11 bits of weights

Range can be 0 - 1

fitness = MSE etc $(y-\hat{y})^2$

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[2] [2 Points] Show complete working to select a chromosome from the following population of three chromosomes using fitness proportionate or Roulette Wheel selection. The fitness value of each chromosome is already given to you. Show complete working

Chromosome	Fitness	Chromosome	Fitness	Chromosome	Fitness
11001	10	01011	80	11100	10

If at any point during the selection you need random numbers, use the following uniformly generated random numbers in order. These random numbers are from a uniform distribution over (0 1).

Random numbers: 0.07, 0.95

	f	Sc.P	C.f		
1	10	0.1	0.1	0 — 0.1	R = 0.07
2	80	0.8	0.9	0.11 — 0.9	so P1
3	10	0.1	1	0.96 — 1	11001
	100				

[3] [2 Points] For each pair of chromosomes generate two offspring (new chromosomes) using the random number given along with the pair

Chromosome A	Chromosome B	Random Number
11010101	00111011	A uniform random number 0.065 from the interval (0 1)
0011001	1101011	A fair dice is rolled and the top face show 3 as output

R = 0.065 x N = 8 = 0.52
cut at one
1|1010101
0|0111011
op1 = 10111011
op2 01010101

R = 1/6 = 0.1667 x 7 = 1.366
cut one
0|011001
1|101011
0101011
1011001

OR
Bit 3rd
After
0011011
1101001

[4] [2 Points] With the input X = [1 0 1], compute the output of a Perceptron without an explicit bias term using its weights w = [0.5, -0.4, 0.9] where the standard perceptron uses sign/step as the activation function. Show working

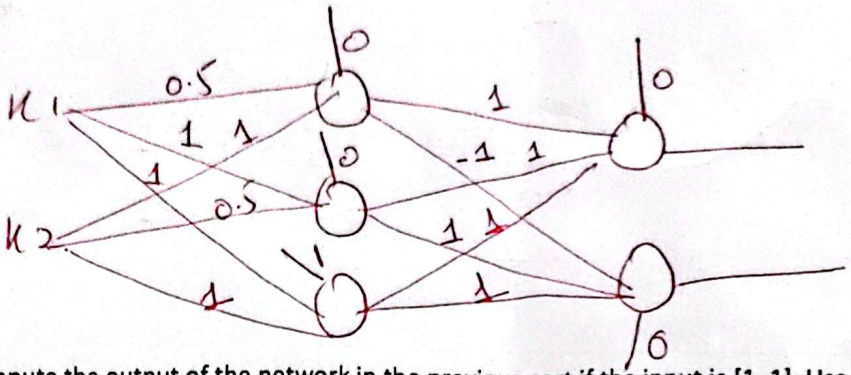
output = (1 x 0.5) + (-0.4 x 0) + (1 x 0.9)
= 1.4

Step if (1.4 > 0) 1 else 0
Sigin if (1.4 > 0) 1 else -1

output is y = 1

[5] [2 Points] Draw the architecture (number of hidden layer neurons and number of output layer neurons their weights and bias terms) of a multi-layer perceptron if it has two inputs and following weight matrices and biases

Hidden layer weights and biases			Output layer weights and biases	
Weights		Biases	Weights	Biases
0.5	1	0	1 1 1	0
1	0.5	0	-1 1 1	0
1	1	1		



[6] [2 Points] Compute the output of the network in the previous part if the input is [1 1]. Use activation functions of your choice at each layer and clearly mention your choice of activation function used. Show all working

$h_1 = (1)(0.5) + 1(1)$

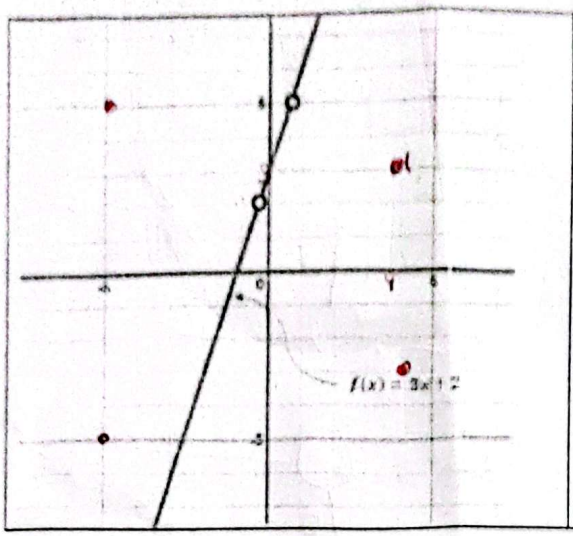
$$h_2 = \begin{bmatrix} 0 & 0.5 & 1 \\ 0 & 1 & 0.5 \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 1.5 \\ 1.5 \\ 3 \end{bmatrix} \xrightarrow{\text{sigmod}} \begin{bmatrix} 0.8176 \\ 0.8176 \\ 0.9525 \end{bmatrix}$$

$h_3 =$

$O_1 = 2.5865 = 0.07 \; 0.92998$

$O_2 = 0.9525 = 0.7216$

[7] Consider the following figure. Here the line Y = 3x + 2 divides the 2D space into two parts. Suppose we want to learn a classifier that will label an input as -1 if the point lies above this line and label it as 1 otherwise.



a. **[2 Points]** Prepare training data consisting of two positive and two negative examples for training the classifier.

(3,4) 1

(4,-3) 1

(-5,5) -1

(-5,-5) -1

b. **[4 Points]** Use your training examples to learn a perceptron for this problem using a single epoch (iteration over training examples) starting with initial weights and bias are set to **ZEROS**. Show working and process examples in order i.e first, second, third and then forth

$\alpha = 0.2$ $w = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$ $I = \begin{bmatrix} 3,4 & -5 & -5 \\ 4,-3 & 5 & -5 \\ 1 & 1 & -1 \end{bmatrix}$ act $\begin{cases} -1 & \text{if } 3x+2>0 \\ 1 & \text{else} \le 0 \end{cases}$

1st $w^T \cdot I$

$(1)(0) + 3(0) + 4(0) = 0$ $\hat{y} = 1 == y$

No (update)

$\vec{w} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} + 0.2 \begin{bmatrix} \cdot \end{bmatrix} \alpha$

2nd

$(4)(0) + (-3)(0) + (1)(0) = 0$ b.T

$\hat{y} = 1 == y$

3rd

$(-5)(0) + 5(0) + (1)(0) = 0$

$\hat{y} = 1 \neq y = -1$

update

$\vec{w} = \vec{w}_{old} + \alpha(y - \hat{y})\vec{I}$

$\vec{w} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} + 0.2(-1-1) \cdot \begin{bmatrix} 1 \\ -5 \\ 5 \end{bmatrix}$

$= 0.2(-2) \cdot \begin{bmatrix} 1 \\ -5 \\ 5 \end{bmatrix} = \begin{bmatrix} -0.4 \\ 2 \\ -2 \end{bmatrix}$

4th b.T

$= (-0.4)(1) + (2)(-5) + (-2)(-5)$

$= -0.4 - 10 + 10 = -0.4$

$\hat{y} = -1 == y = -1$

No update

EITHER ATTEMPT QUESTION 8 OR 9 BUT NOT BOTH

[8] Suppose you are working with a sports science institute that is researching the effect of an athlete's age on their **endurance score** during training. The data below has been collected from five athletes. Your task is to apply **Simple Linear Regression** on this data set.

Age (years)	Endurance Score
36	11
33	13
30	14
27	16
25	20

a. **[2 Points]** Calculate and provide the values of intercept and slope of LR Model.

b. **[2 Points]** What is the value of correlation coefficient (R) of your LR model.

c. **[2 Points]** Use this model to **predict the endurance score for an athlete who is 24 years old.**

[9]

a. **[5 Points]** A binary classifier is tested on 10 test examples. Following are the actual and predicted outputs of the classifier. Compute FP, FN, Accuracy, Precision, Recall and F1- Measure for this classifier

Actual	1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1
Predicted	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1

Pre

Ac		1	-1
	1	TP 0	FN 5
	-1	FP 1	TN 8

each = 0.83

$$Acc = \frac{TP+TN}{TP+TN+FP+FN} = \frac{8}{11} = 0.727$$

$P = 0$

$R = 0$

$F = 0$

b. **[1 Points]** Name an evaluation measure along with the formula to compute it that is commonly used for regression but might not be suitable for classification problems

MSE
RMSE
SE

	Y	Ed Score	$X-\bar{X}$	$Y-\bar{Y}$	X	$(X-\bar{X})^2$
	36	11	5.8	-3.8	-22.04	33.64
	33	13	2.8	-1.8	-5.04	7.84
	30	14	-0.2	-0.8	0.16	0.04
	27	16	-3.2	1.2	-3.84	10.24
	25	20	-5.2	5.2	-27.04	27.04
$\bar{X}$	30.2	14.8			-57.8	78.8

$$b = \frac{-57.8}{78.8} = -0.7335$$

$$a = \bar{Y} - b\bar{X} = 14.8 - (-0.7335)(30.2)$$
$$= 36.95177$$

$$Y = 36.95177 + (-0.7335)X$$

$$\hat{Y} = 19.3477$$

$$R = -0.9179$$

$$SST = SSR + SSE$$

$$\Sigma(Y-\bar{Y})^2 = \Sigma(\bar{Y}-\bar{Y})^2 + \Sigma(y-\hat{y})^2$$

$$r^2 = \frac{SSR}{SST} \qquad = sig(b)\sqrt{r^2}$$