National University of Computer and Emerging Sciences, Lahore Campus

Course Name:	Artificial Intelligence	Course Code:	CS 401
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Section:	D, E	Page(s):	6
Exam Type:	Mid-II		

Student : Name:_____ **Registration No.**_____

Instruction/Notes: **Write your final answers in the space provided on the question paper. If needed attach of your rough work/sheets at the end.**

QUESTION [Perceptron and Perceptron Learning] [2 + 2 + 2 + 4 Points]

Figure 1 show a single perceptron with two inputs X1 and X2 and a bias term that is permanently set to.

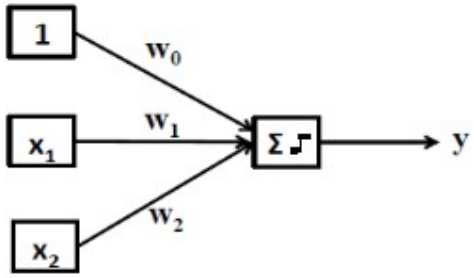


Figure 1

Output of this perceptron is computed using a simple threshold and is given as

$$y = \begin{cases} 1 & \text{if } (w_0 + w_1 \cdot x_1 + w_2 \cdot x_2) >= 0 \\ 0 & \text{otherwise} \end{cases}$$

For each of the grammar create a left-most derivation tree of the string using the given grammar.

Part a) Which one(s) of the following choices of weight vector **[w_0 w_1 w_2]** can be used to compute y as **y = (x_1 NAND x_2)** where ***NAND*** is the logical function denoting NOT AND or Boolean operation, which equals to zero when both x_1 and x_2 equals 1 and is one otherwise

i) [-1 1 0]

ii) [1.5 -1 -1]

iii) [-2 1 1.5]

iv) NONE of ABOVE

v) ALL OF ABOVE weights can be used.

Part b) Which one(s) of the following choices of weight vector **[w_0 w_1 w_2]** can be used to compute y as **y = (x_1 NOR x_2)** where ***NOR*** is the logical function denoting **NOT OR** or Boolean operation, which equals to 1 when both x_1 and x_2 equals **0** and is one otherwise

i) [1 -1 0]

ii) [-1 1 1]

iii) [0.5 -1 -1]

iv) NONE of ABOVE

v) ALL OF ABOVE weights can be used

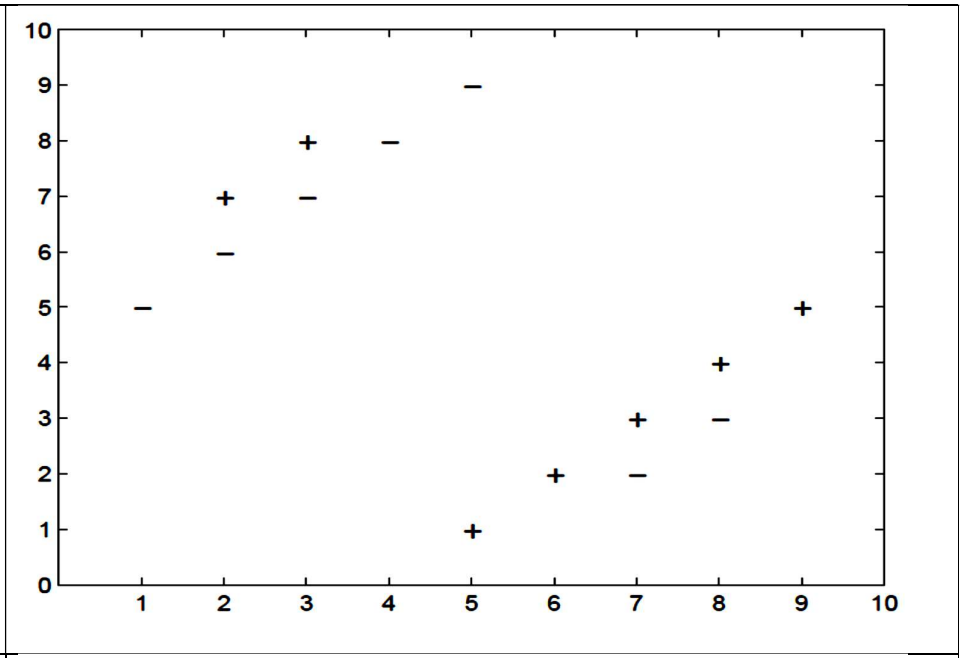
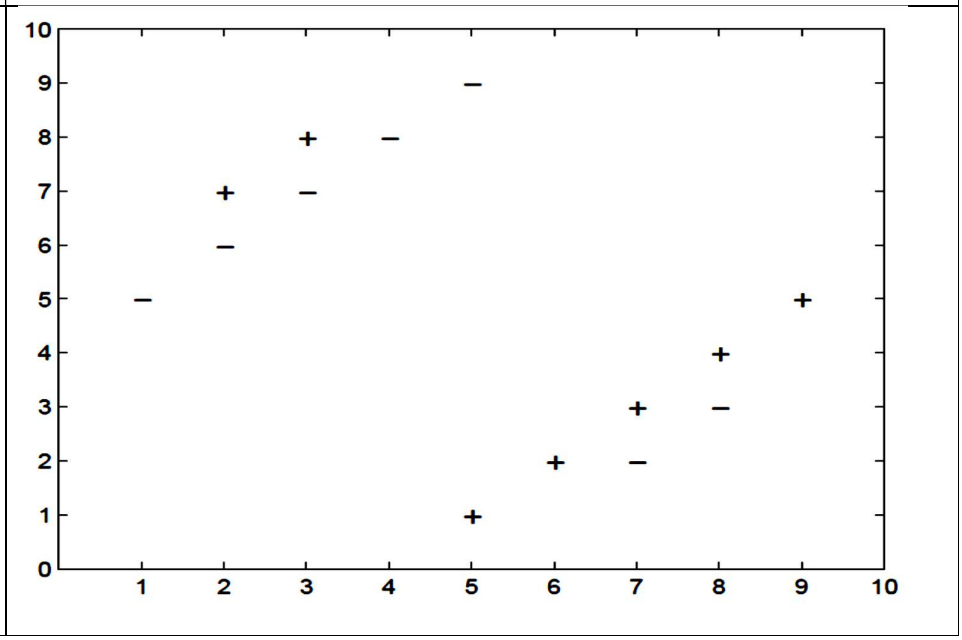
Part c) It is desirable to learn weights **[w_0 w_1 w_2]** of a perceptron that is similar to the perceptron in Figure 1. This perceptron will have two real valued inputs x_1 and x_2 and a bias term set permanently to 1. The objective is to learn weights such that perceptron gives a **1** as output if $x_2 >= x_1$ and -1 otherwise. In this part you are required to create training data that can be used to learn weights of the perceptron. The training data must consisting of **two positive examples (**i.e. examples for which output must be 1) and **two negative examples** (i.e. examples for which output must be -1)

Part d) Use perceptron learning rule to learn weights **[w_0 w_1 w_2]** of the perceptron using your training data of part c. You must start with initial weights [0 0 0] and only do two iteration/epochs for learning the weights

QUESTION 2[KNN classification] **[5 + 2 Points]**

In the following questions you will consider a k-nearest neighbor classifier using Euclidean distance metric on a binary classification task. Note that a point can be its own neighbor.

Part a) For each of the following values of K compute, and mention on the figure, label of each of the training example. Also compute the training accuracy of the resulting classifier

K = 3	
K = 14	

Part b) Explain, how do we select a suitable value of K for a given task when using the K-NN classifier?

Question 3: [Decision Tree Learning using ID3] **[5 + 2 Points]**

For a classification task we wants to be able to discriminate between Martians (M) and Humans (H) based on the following characteristics: Height ∈ {S, T}, Smelly∈{N, Y}. Our available training data is as follows

Species	Smelly	Height
M	Y	S
M	N	T
M	N	T
M	Y	S
M	N	T
H	Y	T
H	N	S
H	N	T
H	N	S
H	Y	T

Fit a decision tree on this data using ID3 decision tree learning algorithm and also compute training accuracy of the resulting decision tree. Show all working.

QUESTION 4 [Genetic Algorithms for Learning a Perceptron] [4 + 3 Points]

It is well known that the weights of a perceptron can be learned using **Genetic Algorithms**. As in any application of GAs the first step would be the design a chromosome (representation of solution) for this problem. Once the chromosome representation is finalized we also need to define the fitness function, the crossover operator and the mutation operation.

For the perceptron of question No 1 with a bias term and two real valued features x_1 and x_2 as shown in Figure 1

Part a) Describe a detailed chromosome representation for learning its weights using **GA**.

Part b) How would you compute fitness of your chromosome when learning the weights of this perceptron in the supervised learning setting?