Assignment 7 AI 2002

Artificial Intelligence

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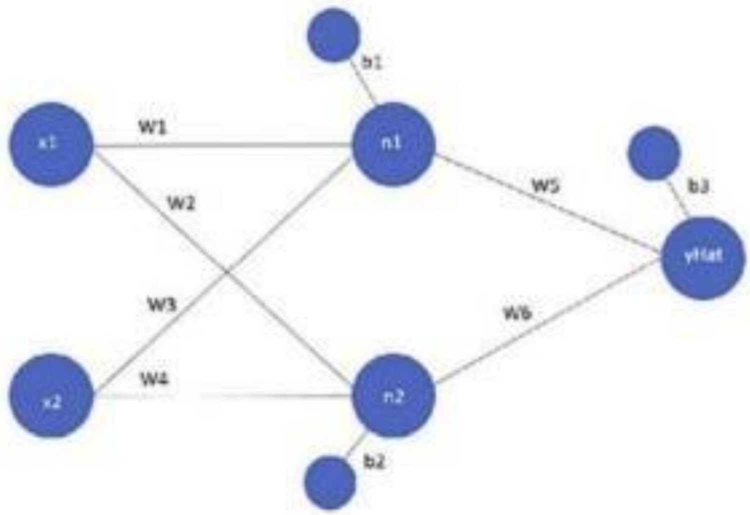
Topic Covered	Artificial Neural Network, Perceptron, Perceptron Learning rules. Multi-Layer Perceptron, Backpropagation
Submission Deadline:	**16-05-2024 till 11:59PM**
Submission Guideline	**1. Group assignment: 2 members (at max.)** **2. Submit your code solution for Questions 6, and a PDF file for Questions 1 to 5, on** **3. the Google Classroom (of your respective** **4. section).** **Students are expected to submit their own code and answers, any help from internet/fellows is not allowed.**

Question No 01:

Consider the neural network architecture for XAND function given below:



1. Assume that the activation function is the sigmoid function. Initialize all the weights with 0.1. Write down the values of the weights after the first and the second iteration of Backpropagation algorithm run with the following examples:

X1	**X2**	**Y**
0	0	1
1	0	0
0	1	0
1	1	1

2. Consider a neural network that uses a function tanh instead of the sigmoid unction. What will be the values of the weights after the first and second teration in such a case?

Question No 02:

1. Derive a gradient descent based learning rule for a perceptron that uses tanh as activation function. Assume that the perceptron has D inputs and a bias term and we have N training examples (Xi, Yi) I = 1, 2, ... , N to learn weights of the perceptron. Please note that the derivative of tanh(x) is 1 – tanh2(x)

2. Show the mathematical working of Artificial Neural Network by taking the case in figure below. First two columns are the input values for X1 and X2 and the third column is the desired output. Show only 3 iterations.
   Learning rate = 0.2
   Threshold = 0.5
   Actual output = W1X1+W2X2
   Next weight adjustment = Wn+□Wn
   Change in weight = □Wn = learning rate * (desired output- actual output) * Xn
   Show two complete iterations for acquiring the desired output.

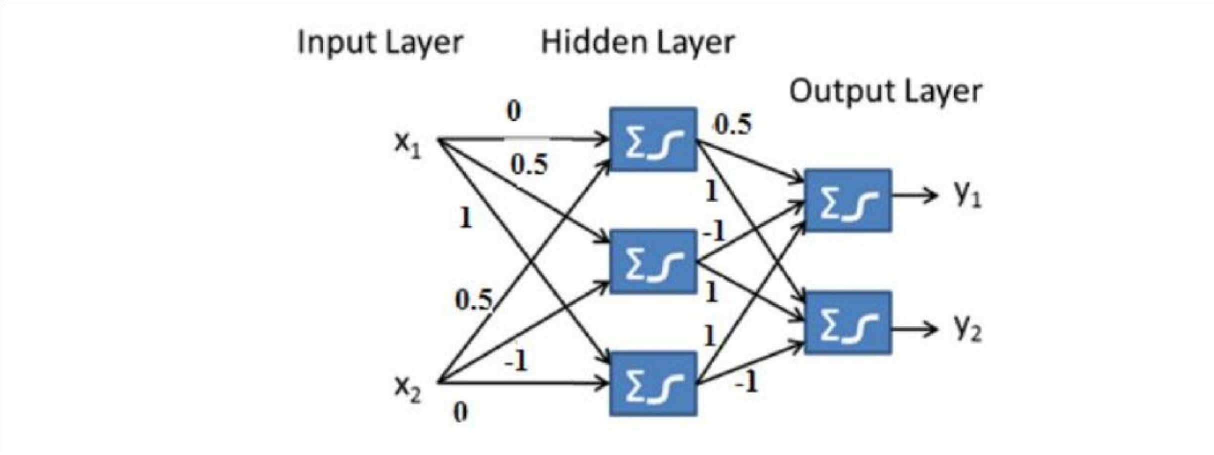
X1	X2	W1	W2	D	Y	□W1	□W2

	X1	**X2**	**Output**
	0	0	0
	0	1	1
	1	0	0
	1	1	1

Question No 03:

Consider the neural network architecture with two inputs (x1, x2) three hidden layer neurons and two output neurons (Y1, Y2). Assume that each neuron has a bias term set equal to -1 and each neuron uses the sigmoid activation function given as

$$f(x) = \frac{1}{1+e^{-x}}$$



Weights of all neurons as shown on the figure are:

Hidden Neurons

Top Neuron	**0**	**0.5**
Middle Neuron	**0.5**	**-1**
Bottom Neuron	**1**	**0**

Output Neurons

Top Neuron	**0.5**	**-1**	**1**
Bottom Neuron	**1**	**1**	**-1**

For the training example with input X = [1, 1] and Target Y = [0, 1]

1. **Compute Output**

   Compute the neural network output where α = 1

2. **Error Calculation and Back Propagation** • For each of the output neurons, compute the error term δk used by the back propagation algorithm to update the weights.

   • Compute the error term δh for each of the hidde n neurons.

3. **Weight Update**

   Use the errors computed above to compute the updated weights of the neural network. Take the value of learning rate η = 0.5.

Question No 04:

Consider a single perceptron unit with a bias term and n inputs **[x0, x1, ... xn].** The perceptron uses weights **[w0, w1, ... wn]** and the given sigmoid activation function to compute the output.

$$(\text{i.e. } f(x) = \frac{1}{1+e^{-x}})$$

Derive the weight update equation for such a perceptron using the following definition of

$$\textbf{Error} = \sum_j^m (y_j - y_j^*)^2 + \sum_{i=0}^n w_i^2$$

where yj is the target output and yj* is the output computed using weights and the activation function of neuron.

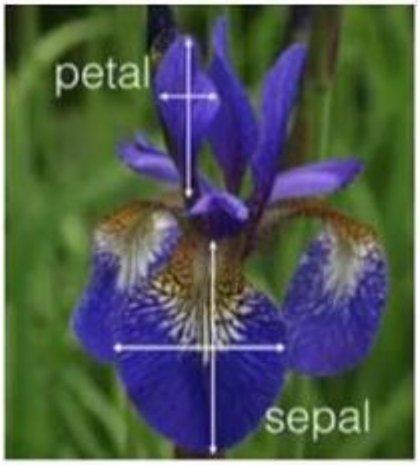
Hints:

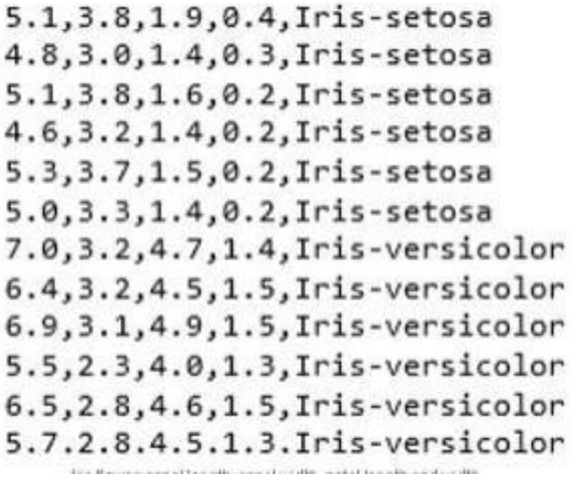
- Derivative of sigmoid activation function can be written as
$$f'(x) = f(x) \,.\, (1 - f(x))$$
- Weights are updated using the equation
$$\boldsymbol{W_i = W_i - \eta \Delta E_i}$$

Therefore, to derive the final equation you need to compute the derivative of Error with respect to each of the weights components wi and then use the weight update equation given above to derive the final equation

Question No 05:

Iris dataset has 50 samples for each of three different species of Iris flower (total number of samples is 150). For each data sample, you have sepal length, sepal width, petal length and petal width and a species name (class/label). Figure below shows Iris flower and features in dataset:





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5.1,3.8,1.9,0.4,Iris-setosa
4.8,3.0,1.4,0.3,Iris-setosa
5.1,3.8,1.6,0.2,Iris-setosa
4.6,3.2,1.4,0.2,Iris-setosa
5.3,3.7,1.5,0.2,Iris-setosa
5.0,3.3,1.4,0.2,Iris-setosa
7.0,3.2,4.7,1.4,Iris-versicolor
6.4,3.2,4.5,1.5,Iris-versicolor
6.9,3.1,4.9,1.5,Iris-versicolor
5.5,2.3,4.0,1.3,Iris-versicolor
6.5,2.8,4.6,1.5,Iris-versicolor
5.7.2.8.4.5.1.3.Iris-versicolor
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Perform the following tasks:

- Load the given Iris dataset
- Split it into a training set and a test set
- Preprocess the data
- Build a Decision Tree classifier
- Then train a Random Forest classifier
- How much better does it perform compared to the Decision Tree classifier?