Indian Institute of Technology Indore
Discipline of Computer Science & Engineering
CS 403/603 Machine Learning
Lab 1 - Perceptron and Back Propagation Neural Networks

Some general instructions:

- Plagiarism in any form will not be tolerated.
- You are allowed to do only one submission before the deadline. However, in the case of multiple submissions, only the last submitted file will be used for evaluation.
- Submission of the assignment should be made using the Google Classroom platform only.
- Last date for submission of the assignment: **19th Oct 2021**

Question 1: The vectors defined below were obtained by measuring the weight and ear lengths of toy rabbits and bears in the Animal Factory. The target values indicate whether the respective input vector was taken from a rabbit (0) or a bear (1). The first element of the input vector is the weight of the toy, and the second element is the ear length.

$\{p_1 = [1\ 4\ ],\ t_1 = 0\ \},\quad \{p_2 = [1\ 5\ ],\ t_2 = 0\ \},\quad \{p_3 = [2\ 4\ ],\ t_3 = 0\ \},$
$\{p_4 = [2\ 5\ ],\ t_4 = 0\ \},\quad \{p_5 = [3\ 1\ ],\ t_5 = 1\ \},\ \{p_6 = [3\ 2\ ],\ t_6 = 1\ \},$
$\{p_7 = [4\ 1\ ],\ t_7 = 1\ \},\ \{p_8 = [4\ 2\ ],\ t_8 = 1\ \}$

a. Code to initialize and train a network to solve this “practical” problem and find the resulting weight, bias values and accuracy against the input vectors.
b. Create a few vectors and test the network for the same. Record the testing accuracy.
c. Vary the learning parameter and try to converge the network for testing accuracy above 80%.

Question 2: We have a classification problem with four classes of input vectors. The four classes are

$$class\ 1\ = \{p_1 = [1\ 1\ ],\ p_2 = [1\ 2\ ]\ \}$$

$$class\ 2\ = \{p_3 = [2\ \ -\ 1\ ],\ p_4 = [2\ 0\ ]\ \}$$

$$class\ 3\ = \{p_5 = [-\ 1\ 2\ ],\ p_6 = [-\ 2\ 1\ ]\ \}$$

$$class\ 4\ = \{p_7 = [-\ 1\ \ -\ 1\ ],\ p_8 = [-\ 2\ \ -\ 2\ ]\ \}$$

a. Design the neural network and train it using the perceptron learning algorithm. Find the number of iterations required to train the network.
b. Test the network by creating a few samples on your own and find its testing accuracy.

c. Also, vary the following parameters of the network:
   i. Learning Parameter
   ii. Weight Initialization
   iii. Bias
   iv. Activation Function

   and observe the change in training and testing accuracy.

Question 3: Implement a feed-forward neural network with one layer of hidden nodes and a single output node. Use the sigmoid function as the activation function for all the hidden nodes and the output node. Train and test the neural network with the dataset using the following links:

Train Data, Test Data, Train Labels, Test Labels

Since the output node uses a sigmoid activation function that returns a number between 0 and 1, associate any output greater than 0.5 to one class and any output less than or equal to 0.5 to the other class. Use the following parameters:

> learning rate: 0.001
> number of hidden nodes: 5 to 15
> number of iterations in backpropagation: 1000 (where each iteration consists of updating the weights based on all the instances in the training set)
> weight initialization: random numbers in [−0.5, 0.5]

Plot a graph of the train and test accuracy for your neural network as a function of the number of hidden nodes (from 5 to 15 hidden nodes).

Results:

Attach your code file and include a single write-up (pdf) file which includes a brief description for each question explaining what you did. Include any observations and/or plots required by the question in this single write-up file.