

## EE538 Neural Networks

### Homework 4

Due: 12:59 pm, April 16, 2021

Let's consider data shown in a 2-dimensional space. Class 1 data are uniformly distributed in a half doughnut shape at  $x_2 > 0$ , of which center is located at  $(0,0)$  and radius is between 7 and 13. Also, Class 0 data are uniformly distributed in a half doughnut shape at  $x_2 < 4$ , of which center is located at  $(10,4)$  and radius is between 7 and 13.

1. Develop a computer program to generate the data, and show 500 random data for each class. (10 points) [Hint: You may generate uniform random values for  $(x_1, x_2)$ , and select if-and-only-if  $(x_1, x_2)$  is located in the half doughnuts defined above.]
2. Let's assume we do not have the class label. Run a competitive learning program to cluster into 2, 3, 4, and 8 clusters, and show the cluster centers and class boundaries. (10 points)
3. With the class labels, find an ideal linear decision boundary. (10 points)
4. With the class labels, train a single-layer Perceptron to learn a decision boundary with a pseudo-random initialization, and show the decision boundaries. You may try to use several different constant learning rates to see different learning curves, and propose an appropriate learning rate. (10 points)
5. With the proposed learning rate in Problem 4, train a single-layer Perceptron using 5 different random initializations of the synaptic weights, and show the design boundaries. (10 points)
6. Develop a computer program with  $n$  hidden layers. For simplicity, you may assume  $n$  is either 1 or 2 only. (10 points)
7. Train the 1-hidden-layer Perceptron of 2 hidden neurons with sigmoid nonlinearity and 5 different random initializations, and show the decision boundaries. You may need try several learning rates to find appropriate value. (10 points)
8. Repeat Problem 7 with ReLU nonlinearity and compare the results. (5 points)
9. Repeat Problem 7 with 5 hidden neurons and the appropriate learning rate. (5 points)
10. Repeat Problem 7 with 15 hidden neurons and the appropriate learning rate. (5 points)
11. Train the 2-hidden-layer Perceptron of 5 hidden neurons each with 5 different random initializations, and show the decision boundaries. (10 points)
12. Repeat Problem 11 with 10 hidden neurons each. (5 points)

