EE538 Neural Networks

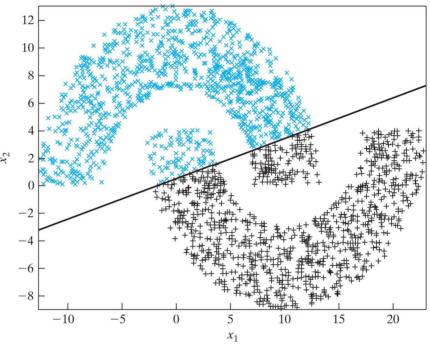
Homework 4

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

Classification using LMS with distance = -4, radius = 10, and width = 6



- 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)