Assignment 1 - Linear Models
ECE4179, Neural Networks and Deep Learning, 2020

Due: August 30, 11:59pm

Instructions. Please submit your report along the code (Jupyter notebook is preferred) through the Moodle. Include your name and email address on the report and use a single column format when you prepare your report. Don't send doc/docx files, please convert your report to **PDF** and send it through.

Q1. (10 marks) Would it be possible to train a perceptron using a variant of the perceptron training algorithm in which the bias weight is left unchanged, and only the other weights are modified?

Q2. Use the starter code provided as a Jupyter notebook and implement the following functions using the calculations above. Pay attention to the comments and guidelines in the starter code

1. (5 marks) a function to compute the sigmoid
2. (15 marks) a function to compute gradient and cost of the logistic regression
3. (10 marks) complete the for loop that performs the gradient descent algorithm
4. (5 marks) a function that predicts the class of its inputs according to the parameters of the logistic model

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Q3. Now load the data file called "toy_data.npz" and use the training data (X_train, y_train) to train your logistic model. Note that each sample $\boldsymbol{x}_i$ is a point in $\mathbb{R}^2$ and each label is $y_i \in \{0, 1\}$. Also note that samples are bounded in $\boldsymbol{x}_i \in [-5, 5] \times [-5, 5]$ (meaning that each feature is within the range [-5,5]).

In your report,

1. (10 marks) discuss the effect of the learning rate parameter.
2. (10 marks) report the accuracy of your model on the test data (X_test, y_test). Here you need to use the predict function and see what fraction of the test samples your model predicts correctly.
3. (10 marks) compare the solution with and without the bias term in your model. Recall that to have a bias, you need to augment your samples with "1".
4. (10 marks) plot the decision boundary of your model for points $[-5, 5] \times [-5, 5]$. Here you need to scan all the points (with a reasonable gap) in the region $[-5, 5] \times [-5, 5]$ and check the prediction of your model. Then you can plot the results to visualize how your model predicts points in the input region.

Q4. Now load the data file called "toy_data_two_circles.npz" and use the training data (X_train, y_train) to train a logistic model. Note that each sample $\boldsymbol{x}_i$ is a point in $\mathbb{R}^2$ and each label is $y_i \in \{0, 1\}$.

In your report,

1. (5 marks) report the accuracy of your model on the test data (X_test, y_test).
2. (15 marks) Your friend suggests that to better classify this data, we need to use nonlinear features. In particular, (s)he suggests to map a sample $\mathbb{R}^2 \ni x = (x_1, x_2)$ to $\mathbb{R}^5 \ni \hat{x} = (x_1, x_2, x_1^2, x_2^2, x_1 x_2)$. Use the above mapping and then train a new logistic model. Compute the accuracy of the resulting model and compare it with the model from part Q3.1.