Neural Networks and Deep Learning

Homework and Programming Assignment 2

**Total Points: 100**

**Deadline: Feb 21, 2022**

1. [**Points 10**] We learned two linear model – linear regression and logistic regression. Compare both methods. Can we use linear regression model to detect person face in an image? Describe your rationale behind it.

2. [**Points 15**] In logistic regression classifier, we are fitting a s-shape curve to fit the data. We are given 10 sample points with corresponding probabilities as follows, 0.34, 0.21, 0.54, 0.45, 0.60, 0.70, 0.80, 0.95, 0.99.

1. What is log odds? Compute log odds values for those given data points. [**Points 7**]
2. Compute log likelihood for this given data points. [**Points 8**]

3. [**Points 15**] We know logistic regression is a binary classifier. Can we use it for multiclass classification? Provide detail rationale behind your answer and include any drawback of your proposed approaches.

4. [**Points 10**] SoftMax is a multiclass classifier, and it converts logits to probabilities. We are given logit values 3.5, 6.1, -2.9, -1.2 for 4 classes “bus”, “truck”, “car”, “van”, respectively. Compute the probability of those given logits and classify it.

6. [**Points 25**] We are designing a 2-layer feedforward neural network. Our input features are 3-dimensional. The first hidden layer has 5 neurons with sigmoid activation function. Final layer contains two neurons with Relu activation function. Assume that given inputs are x1, x2, x3 and hidden layer weights are wlij, where l ∈ {1, 2} is the layer number and i ∈ {1,2,3} is the number of inputs. j ∈ {1,2,3,4,5} indicates the number of neurons. blj indicates bias for corresponding layers and neurons. For any inconsistency with the notation given, you can modify it and mentioned the notation scheme in your answer.

1. Draw a complete diagram of this feed forward neural network showing all individual weights, biases. [**Points 10**]
2. Show forward computation for this given input x1, x2, x3. Show detailed equations for each computing unit (neuron) for each layer. [**Points 15**]

7. [**Points 25**] In this homework, we are going to implement a neural network for the handwritten digit classification problem with the MNIST data. Please use the MNIST data that includes 100 images on each label of 0 – 9. Dataset is given as a csv file. Each row represents an image with given class label in the first column.

You should implement a neural network (NN) and first create your training and testing with a random split of 80% training and 20% testing data. Compute accuracy for test dataset.

Compare performance 3-layer NN, and 4-layer NN. For classification task use SoftMax classifier at the end of your NN. You can design the network by yourself.

Example NN architecture:

Diagram

Description automatically generated

The above example network includes three layers: input, hidden, and output layer. Given input images are 28\*28 dimension. Output layer comprises of SoftMax layer.

**Instructions:**

You can choose the number of nodes/neurons in the hidden layers, activation functions, loss function etc. Train your model for at least 100 epochs.

You can implement the neural network using any deep learning frameworks (e.g., tensor flow, torch, etc.)

1. Clarify network design (NN) and hyper-parameters. [**Points 5**]
2. Draw a curve(s) of error (training and testing) vs number of epochs for both neural networks. [**Points 10**]
3. Compute test accuracy for both networks and discuss comparative logic behind that performance. [**Points 10**]

Please submit this question (7) in a notebook with a properly executable code and output of each block. Note that non-executable code may not be graded.

**Submission Instructions:**

**Important.** Please make sure that the submitted notebooks have been run and the cell outputs are visible with sample test example. Without visible outputs, you may get zero for those corresponding questions. Convert the notebook into a single PDF. You can submit your text question answer in a separate PDF/Doc if needed.

Compile your assignment (i.e., firstname\_assignment2.ipynb, firstname\_assignment.pdf ) in a zip file and submit it.