Neural Networks and Deep Learning
Lab Assignment 1: Feedforward Neural Networks

Summary: In this assignment, you will demonstrate you understand how to train, evaluate, and analyze feedforward neural networks. Your submission should include one PDF file that merges two separate PDF documents: one showing your code and another showing your methods, results, and analysis.

1. **Neural Network Hyperparameters [15 points]:**

   (a) Design and conduct your experiment (Code)

   - Load a real dataset not covered in class that is designed for the classification problem; e.g., from sklearn.datasets, Kaggle, your own data, etc.
   - Create an 80/20 train/test split of the dataset.
   - Train at least eight neural network models using all possible combinations of different numbers of hidden layers (at least 2 different values), numbers of neurons per layer (at least 2 different values), and two types of activation functions. Set all other hyperparameters constant when training; e.g., number of iterations for training, batch size, and gradient descent approach.
   - Evaluate each model on the test set using accuracy and a confusion matrix.

   (b) Report your methods, results, and analysis (Write-up)

   - Describe the methods you used for your experiment. This should include a discussion of the dataset (e.g., source? number of examples?) and what parameters were used to train all the models.
   - Report your results for every tested model.
   - Discuss your analysis of what general trends emerge from your results. For example, did a certain number of hidden layers, number of neurons per layer, or activation functions lead to consistently better results. If so, why do you think this occurs? You also could analyze examine what, if any, insights are gained by looking at both the different evaluation approaches (i.e., accuracy and confusion matrix). Your discussion should consist of 2-4 paragraphs.

2. **Impact of Training Duration and Training Data [10 points]:**

   (a) Design and conduct your experiment (Code)

   - Load a real dataset not covered in class that is designed for the classification problem; e.g., from sklearn.datasets, Kaggle, your own data, etc.
   - Create an 80/20 train/test split of the dataset.

- Train neural networks using four approaches: train with 25%, 50%, 75%, and 100% of the training data respectively. For this experiment, select one set of hyperparameters to use for the neural networks and keep those constant when training; e.g., number of hidden layers, number of neurons per layer, activation function, batch size, and gradient descent approach.
- Create one plot with four curves that shows the performance of each of the four approaches with respect to the number of epochs used during training. For performance evaluation, use the accuracy metric.

(b) Report your methods, results, and analysis (Write-up)

- Describe the methods you used for your experiment. This should include a discussion of the dataset and the parameters used to train all the models.
- Show the plot that visualizes the performance for each of the four approaches.
- Discuss your analysis of what general trends emerge from your results. For example, what is the influence of the amount of training data and the training duration? Your discussion should consist of 2-4 paragraphs.

How to Submit Lab Assignment 1: Please submit a pdf named with your first and last name; i.e., firstname_lastname.pdf. A successful submission will consist of two contributions. First, it should include the source code of your implementation **as the first part of the PDF file** (i.e., portions indicated by "Code").[1]. Second, it should include a report with all results and analysis (i.e., portions indicated by "Write-up") **as the second part of the PDF file**. All material that you submit must be your own.

[1]We require submitting the code as a PDF to avoid many issues that we have observed in the past with being able to access submitted code. These issues have arisen, in part, because we make no programming language requirements. Issues also have arisen from students not providing read permissions for links to their files; e.g., on Google Colab