Introduction to Machine Learning
Lab Assignment 4: Classification Using Hand-Crafted Features and Neural Networks

1. **Classification Using Hand-Crafted Features [70 points]:** You will compete with the members in your class on a challenge to predict whether a visual question is answerable. For this task, you are required to create a multi-modal (computer vision + natural language processing) classification system. In this case, this means you must use a combination of image-based and language-based features.

   (a) You must use the VizWiz dataset with its pre-defined train/validation/test split. You can find the dataset at the following link and the paper describing the dataset at the following link. Alternatively, you can find the train, validation, and test annotation files as well as all images posted at the following webpage: https://ivc.ischool.utexas.edu/VizWiz/data/.

   (b) Define a feature representation for each visual question that uses: (Code)

      i. Image-based features extracted using either the Microsoft Azure API or a Python library (e.g., scikit-image, OpenCV). If using the Microsoft API, begin early as there can be complications with accessing the server for a large-scale dataset.

      ii. Question-based features extracted using the Microsoft Azure API or a Python library (e.g., NLTK). If using the Microsoft API, begin early as there can be complications with accessing the server for a large-scale dataset.

   (c) You can use any transformations (e.g., feature dimension reduction techniques) and classification models (e.g., SVM, ensemble) of your choice to train your system to predict whether a visual question is answerable using the input features. For full credit, you need to train using at least 500 training visual questions. (Code)

   (d) You must submit the test prediction results from your classification system for the first 100 examples in the test split: i.e., VizWiz_test_000000020000.jpg – VizWiz_test_000000020099.jpg. This must be submitted in a csv or excel file with the prediction listed in the first 100 rows in column A, where 1 indicates answerable and 0 indicates unanswerable. (Code)

   (e) Write 2-3 paragraphs describing your proposed prediction method. Describe the implementation of your proposed approach in such a way that a 1) reader could reproduce your set-up and 2) understand why you made your design decisions.

   (f) Write 2-3 paragraphs describing the analysis you conducted with the training and/or validation datasets that guided your choice for your prediction system design (e.g., hyperparameters, classification models, etc).

   (g) Extra credit 1: first place winner of this challenge will receive 10 extra points and second place winner of this challenge will receive 5 extra points. Performance will be judged using accuracy as the evaluation metric.

2. **Classification Using Neural Networks [30 points]:**

   (a) Load MNIST and create a 70/30 train/test split. (Code)

   (b) Optimize hyperparameters: find the optimal number of hidden layers (at least 10 different values) and number of neurons per layer (at least 10 different values)

when training a multilayer perception (MLP). Set all other parameters constant when training; e.g., activation function, number of iterations for training, batch size, and gradient descent approach. (Code)

(c) Report the optimal hyperparameters you found and the number of weights that are in this optimal model. (Write-up)

(d) Write a discussion about the performance of the neural network when using different hyperparameters. For example, what number of hidden layers and neurons per layer did better/worse and why do you think so? Your discussion should consist of 2-4 paragraphs. (Write-up)

How to Submit Lab Assignment 4: Please submit a pdf that provides the code (or hyperlinks to the code) and answers to the questions, as deemed appropriate for the task. The pdf file should be named using your first and last name; i.e., firstname_lastname.pdf. Also, email your prediction results in the csv or excel file to the Instructor at danna.gurari@ischool.utexas.edu. The material you submit must be your own.