CSE 40625 — Machine Learning
Assignment 4 (10 points)
Due Date: April 6, 2017 (Sakai Drop Box)

Single-Layer Neural Network

Overview
The purpose of this assignment is for you to implement a single-layer neural network, a supervised machine learning inspired by the way the brain works. Neural networks are systems of interconnected "neurons" or units that can compute values from inputs by feeding information through the network. The model makes predictions by chaining together layers of neural units. A single-layer neural network has a single output layer, with no hidden neurons. By applying a specific output function—the softmax function—our single-layer neural network will be able to implement multinomial logistic regression. Materials for the assignment, including the dataset, expected output, and template code can be found here on GitHub.

You may use Python libraries for handling data preprocessing and visualization, including but not limited to NumPy, SciPy, pandas, and Matplotlib, but *you may NOT use any Python libraries that employ machine learning models, including but not limited to scikit-learn, StatsModels, TensorFlow, or Orange*. Your solution to the assignment should be individually submitted.

Dataset
You will use the "digits" dataset on handwritten digit classification with all 10 classes (labeled from 0 to 9) for this assignment. The data is provided in comma-separated (CSV) file format. For all rows, the last column designates the class (y) and the remaining columns designate features (X). The first row consists of the feature and class names.

Procedure
Use the above digits dataset as input to a single-layer neural network model. Initialize the weights and bias with random samples drawn from a uniform distribution over [0.0, 1.0). Feed the input through the network. Compute the output predictions by applying the softmax function to the inputs plus the bias. Using multinomial logistic loss (also known as cross-entropy loss), minimize the gradient of the error function. Update the weights and biases using the gradients with a learning rate of 0.01. Repeat for at 500 iterations. Predict each target value based on the unit in the output layer with the highest activation output.

Output
Your code should output the accuracy of the prediction results every 50 iterations while fitting the model, a blank line, and the confusion matrix of the final output results.

Example output:

```
0 0.226
50 0.899
100 0.920
150 0.930
200 0.933
250 0.935
300 0.936
350 0.938
400 0.938
450 0.940

Predicted   0   1   2   3   4   5   6   7   8   9
Actual
0         524   8   1   0   3  10   0   0   7   1
1           0 535   3   0   1   0   0   0  16  16
2           0  14 524   6   0   1   1   0   8   3
3           0   2   1 539   0   9   0   3  11   7
4           1  15   0   0 530   0   5   1   4  12
5           0   4   3   2   2 525   0   1   9  12
6           0  14   1   0   7   0 527   0   9   0
7           0   4   0   1   6   3   0 531  11  10
8           0  22   0   0   1   1   0   0 523   7
9           0   8   1   7   8   2   0   3   7 526
```

Submission
Please submit a Python executable (singlelayer_neuralnet.py) file of your code to your Sakai Drop Box.

Should you run into any problems, please feel free to email or meet with the instructor.