School Name: Los Alamos High School
Team Number: 201
Area of Science: Artificial Intelligence
Project Title: Implementing an Artificial Neural Network to Recognize Handwritten Digits

Problem Definition:
Computer vision is a quickly growing field in artificial intelligence that involves using a computer to identify objects in the real world. Machine learning offers a way to teach computers how to see. Rather than being explicitly programmed, machine learning techniques provide systems with the ability to make predictions with training data, so the systems can learn on their own. The goal of this project is to design and construct a computer program that can classify digits from zero to nine given training data and test data. The program will involve a training section and test section used for validation. In the training section, the program will learn its own rules. In the validation section, the program will output an accuracy percentage based on how many digits it correctly identifies and how many total test examples there are.

Problem Solution:
The program will be programmed in Anaconda Python. Anaconda contains the core Python language in addition to many libraries for data science. The program will learn from and be validated on the MNIST (Modified National Institute of Standards and Technology) dataset of handwritten digits. Each image is 28 by 28 pixels for a total of 784 pixels. The data is stored as csv file containing labels in the first column (the digit) and 784 pixel values (0 to 255 inclusive) of the digit in the rest of the columns. An artificial neural network will be implemented as the machine learning technique used to recognize digits from the MNIST dataset. During training, the neural network's last layer of neurons will output 10 values (numbers between 0 and 1) corresponding to digits zero through nine. The index highest value will be considered the digit prediction. Using calculated errors from the testing section, the program will adjust each neuron's weights and bias to improve the neural network's accuracy. During testing, the program will calculate the accuracy of the neural network based on how much of the test data it labels correctly.

Progress to Date:
Code was written in IDE jupyter notebook which allows different chunks of code to be executed in the order chosen. Currently, an untrained neural network was created that can perform the neural network operations of the pixel values from a single digit. The first section of code imports these libraries: numpy, csv, matplotlib. section of the program reads each line of the data from a csv file and stores it into a data matrix. The second section reads the dataset from a csv file into a numpy matrix. The third section can display the pixel values of a digit on a grid, so it can be visualized. The fourth section defines the structure of the neural networks, and can

perform the neural network functions on the pixel values of a single digit. In this section of code, the weights and biases are randomly generated. The program prints out the ten outputs of last layer. These outputs are all close to 0.5 because the network is not yet trained.

Expected Results:

After programming and testing, the final program is expected to successfully learn from each training digit and make a prediction for each test digit. During the training, the program is expected to tune the weights and biases in the neural network. During the test section, the program is expected to successfully calculate an accuracy based on many digits it predicts correctly. This technology could be implemented in many real-world applications such as autonomous cars and face recognition. Future work could include the following: modifying the neural network structure to improve accuracy, using my own handwriting as data, using this model to recognize symbols such as letters and other objects.

Information Referenced:

Brownlee, Jason. "Applied Machine Learning Process." *Machine Learning Mastery*, 12 Feb. 2014, www.machinelearningmastery.com/process-for-working-through-machine-learning-problems/. Accessed 13 Nov. 2017.

"But what *is* a Neural Network? | Chapter 1, deep learning." *YouTube*, uploaded by 3Blue1Brown, 5 October 2017, www.youtube.com/watch?v=aircAruvnKk&t=919s. Accessed 10 Dec. 2017.

"Digit Recognizer." *Kaggle*, 2015, www.kaggle.com/c/digit-recognizer. Accessed 10 Dec. 2017.

Ray, Sunil. "Essentials of Machine Learning Algorithms (with Python and R Codes)." *Analytics Vidhya*, 9 Sept. 2017, www.analyticsvidhya.com/blog/2017/09/common-machine-learning-algorithms/. Accessed 13 Nov. 2017

Nielsen, Michael A. " Neural Networks and Deep Learning" Determination Press, 2015.

Project by Sam Crooks

Sponsoring Teacher: Jacob Stinnett