Assignment 1– CMPUT 328
k-Nearest Neighbors

k-nearest neighbors [7 Marks]:

Implement k-nearest neighbors classification algorithm on the MNIST dataset in Tensorflow. The k-nearest neighbor algorithm work as following:

- First, choose a distance function (for example: Euclidean distance, Manhattan distance, cosine similarity...) on the input space.
- For every test data point, find k points in the train set that have closest distances to this point. These are called k-nearest neighbors of it. Classification result of the test data point are determined by a majority vote of its neighbor.

You will need to vary value of **k** and choose the distance function to reach optimal performance. Usually, the Euclidean distance is good enough for most task.

NOTE: A correct implementation of this algorithm will have an accuracy of around 94->96% on the **validation** set.
ADDITIONALMATERIALS: https://en.wikipedia.org/wiki/K-nearest_neighbors_algorithm

DUE DATE: The due date is Thursday, September 20 at 11:55 pm. The assignment is to be submitted online on eclass. For late submissions' rules please, check the course information on eclass

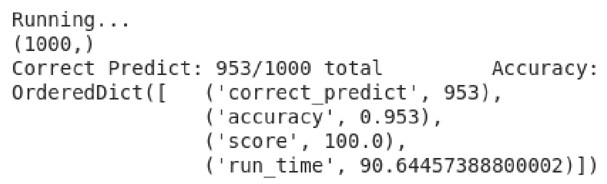
COLLABORATION POLICY: This must be your own work. Do not share or look at the code of other people (whether they are inside or outside the class). Do not search for or copy the code from the Internet. You can talk to others that are in the class about solution ideas (but not so detailed that you are verbally sharing or hearing about or seeing the code). You must cite whom you talked to in the comments of your programs.

SUBMISSION: You need to submit one file: knn.py on eclass.

First, you need to download both files in Assignment 1 Resources on eclass.

The first file named Assignment-1_notebook.ipynb is an ipython notebook for you to work on. Upload this file to Google Colab to use it. This file contains the template code for assignment 1 and a function with signature def knn(x_train, y_train, x_test) which you will need to implement.

After you finish implementing this function, you can run the main loop in the notebook to get your result (including run time and accuracy) like this:



```
Running...
(1000,)
Correct Predict: 953/1000 total         Accuracy: 0.953000      Time: 90.644574
OrderedDict([   ('correct_predict', 953),
                ('accuracy', 0.953),
                ('score', 100.0),
                ('run_time', 90.64457388800002)])
```

Once you are sure your result is satisfactory, move on to the next step with the second file.

This file is a zip file that contains two files within: knn.py and main.py. The important file here is knn.py. Copy and paste the knn function you implemented from your ipython notebook into the knn.py file. Make sure you only overwrite the function and not the import statements as well. Now you can submit this knn.py file onto e-class.

The file main.py is provided just in case you want to run your code from a command line and not in ipython notebook. This file is not required for this assignment and you should not submit it.

Again, knn.py should be the only file you submit. Do not submit pdf or doc or other incorrectly formatted files.

MARKING:

2 Marks Describe your program for TAs (Monday, Sep 17 – Tuesday, Sep 18 – Thursday, Sep 20)

TAs can select five random questions based on your code, results, and kNN algorithm. The time to present will be in your lab section in the week when this lab is due. Note that you must present this part to your TA in your designated lab section. *You will not get mark for this part if you don't present in your own lab section.*

5 Marks A correct implementation of this algorithm will have an accuracy of around 94 -> 96% and an execute time around 90 seconds on the test set. Your mark will be determined by these criterias:

- Accuracy: determines your base score
    - Below 84% on test set: 0 points
    - 84% to 94%: from 0 to 100 points, scale linearly. For example, 85% will give you 10 points, 89% will give you 50 points.
    - More than 94%: 100 points
- Run time: Your final score also depends on the run time. You will retain or lose some of your base score depend on your run time. Note that this runtime constraint is less strict than the expected run time of a correct implementation, which is 90 seconds.
    - Less than 120 seconds: You get 100% of base score
    - More than 120 seconds but less than 180 seconds: You get 50% of base score
    - More than 180 seconds: You don't get any points

The final mark you get for this part will be by *(final score / 100 * 5)*.

What is k-Nearest Neighbors

The kNN algorithm belongs to the family of instance-based, competitive learning and lazy learning algorithms. Instance-based algorithms are those algorithms that model the problem using data instances (or rows) to make predictive decisions. The kNN algorithm is an extreme form of instance-based methods because all training observations are retained as part of the model.

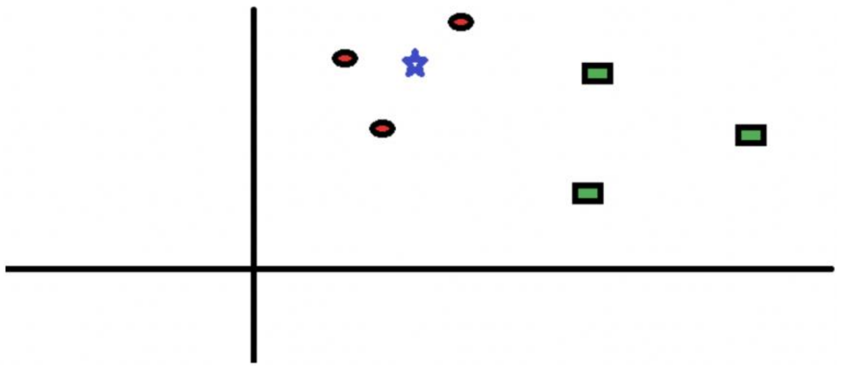
It is a competitive learning algorithm because it internally uses competition between model elements (data instances) to make a predictive decision. The objective similarity measure between data instances causes each data instance to compete to "win" or be most similar to a given unseen data instance and contribute to a prediction.

Lazy learning refers to the fact that the algorithm does not build a model until the time that a prediction is required. It is lazy because it only does work at the last second. This has the benefit of only including data relevant to the unseen data, called a localized model. A disadvantage is that it can be computationally expensive to repeat the same or similar searches over larger training datasets.

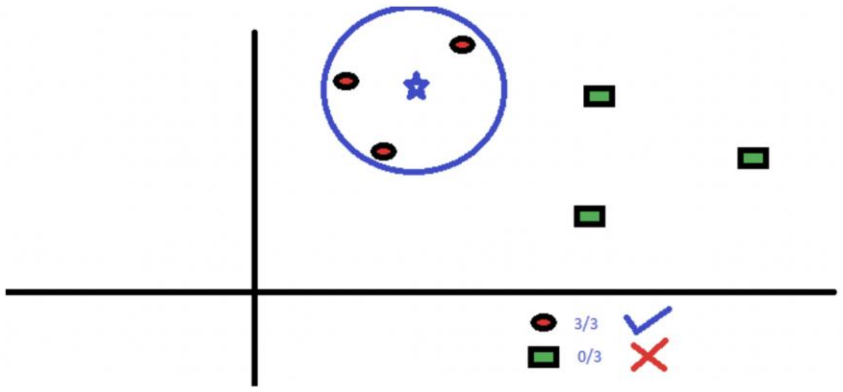
Finally, kNN is powerful because it does not assume anything about the data, other than a distance measure can be calculated consistently between any two instances. As such, it is called non-parametric or non-linear as it does not assume a functional form.

How does the KNN algorithm work?

Let's take a simple case to understand this algorithm. Following is a spread of red circles (RC) and green squares (GS):



You intend to find out the class of the blue star (BS). BS can either be RC or GS and nothing else. The "k" in kNN algorithm is the number of nearest neighbors we wish to take a vote from. Let's say k = 3, and now, we will make a circle with BS as a center, just as big as to enclose only three data points on the plane. Refer to the following diagram for more details:



The three closest points to the BS are all RC. Hence, with the reasonable confidence level, we can say that the BS should belong to the class RC. Here, the choice became very obvious as all three votes from the closest neighbor went to RC. The parameter k is constant, and the choice of it is very crucial in this algorithm.

How to implement k-Nearest Neighbors

Breaking it Down – Pseudo Code of KNN

We can implement a kNN model by following the below steps:

1. Load the data
2. Initialise the value of k

3. For getting the predicted class,
    1. Calculate the distance between test data and training data.
    2. Sort the calculated distances in ascending order based on distance values
    3. Get top k rows from the sorted array
    4. Get the most frequent class of these rows
    5. Return the predicted class