EE 5024 MLIP - Aakash (ME16B001)

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0.1 K – NN Classification:

Download the Datasets from moodle and experiment with K = 1, 3, 5, 9 and 11 for each of the following tasks.

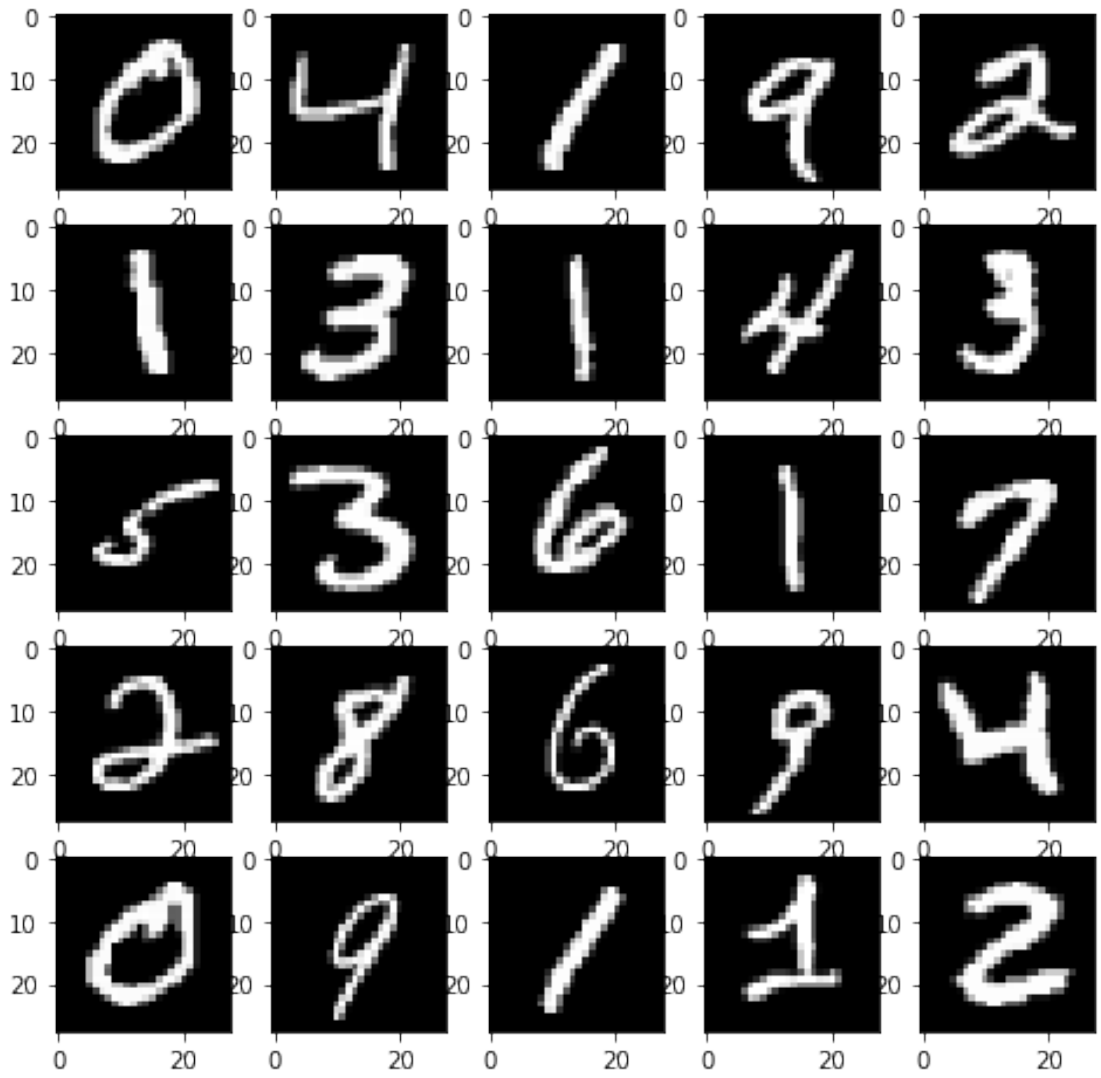
0.1.1 Case I: MNIST dataset

For both train as well as test data the first digit in the ith row this the label (a number in the range 0-9) of the i sample. The next 784 (28x28) digits in the same row are the values of the pixels of the sample (image).

```
In [15]: from scipy.io import loadmat
         import numpy as np
         import matplotlib.pyplot as plt
         import cv2
         from scipy.spatial.distance import cdist

         # load train data
         train = loadmat('mnist_train.mat')
         train=train['traindata']
         print("MNIST train dataset size:",train.shape)
         # load test data
         test = loadmat('mnist_test.mat')
         test=test['testdata']
         print("MNIST test dataset size:",test.shape)

         print("Visualizing the MNIST dataset")
         fig=plt.figure(figsize=(8, 8))
         columns = 5
         rows = 5
         for i in range(1, columns*rows +1):
             img=train[i][1:].reshape((28, 28))
             fig.add_subplot(rows, columns, i)
             plt.imshow(img,cmap='gray')
         plt.show()
```

```
MNIST train dataset size: (5000, 785)
MNIST test dataset size: (500, 785)
```

Visualizing the MNIST dataset



Creating funtions for distance calculation and feature extraction

```
In [20]: def euclidean_distance(Xt,X):
             #     print(X.shape)
             #     print(Xt.shape)
             #     print(cdist(Xt, X).shape)
             return cdist(Xt, X)

         # return histogram feature from the images
         def features(train,test):
             # extract feature from train data
             train_feature = np.zeros((5000, 256))
```

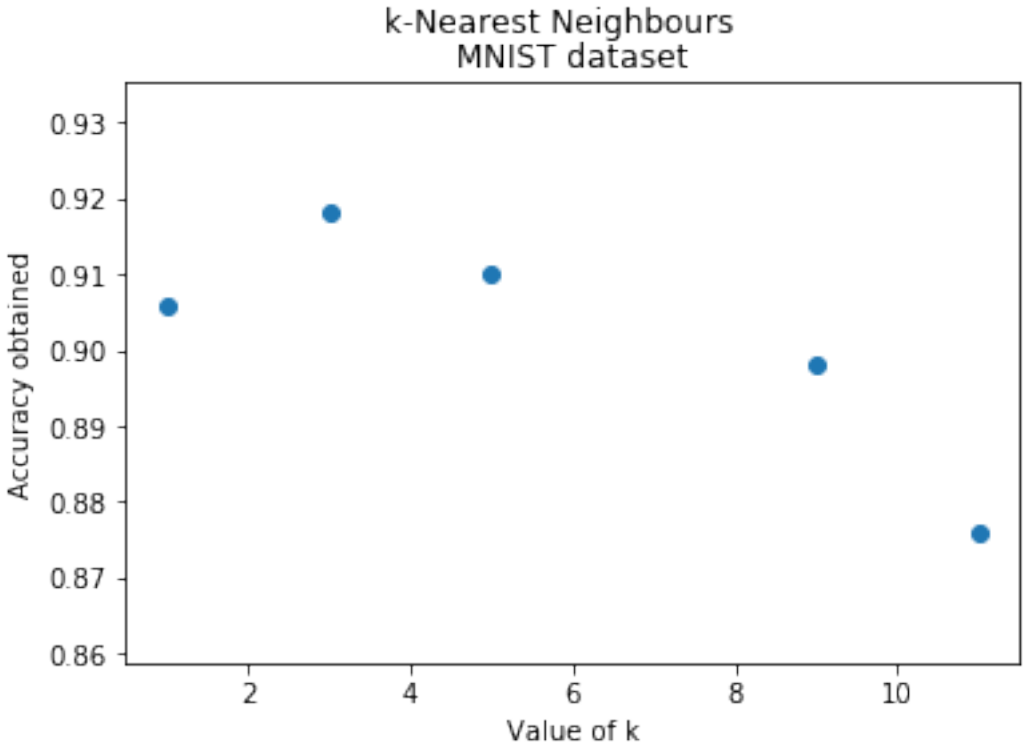
```
            for j in range(train.shape[0]):
                feature = cv2.calcHist([train[j][:]], [0], None, [256], [0, 256])
                train_feature[j]=feature.reshape((1,256))

            # extract feature from test data
            test_feature = np.zeros((500, 256))
            for j in range(test.shape[0]):
                feature = cv2.calcHist([test[j][:]], [0], None, [256], [0, 256])
                test_feature[j]=feature.reshape((1,256))
            return train_feature,test_feature
```

Prediction function

```
In [21]: def predict(k, Xt, X, y):
            # Computing indices of k nearest neighbours of test image
        #     print(Xt.shape, X.shape)
            distance = euclidean_distance(Xt, X)
            idx = np.argsort(distance)[:, :k]

            # Taking majority vote among the labels of knn
            y_pred = []
            for i in range(Xt.shape[0]):
                lab = y[idx[i]]
                sets, cnts = np.unique(lab, return_counts=True)
                y_pred.append(sets[np.argmax(cnts, axis = 0)])
            return y_pred

        def result():
            accuracies = []
            ks = [1,3,5,9,11]
            for k in ks:
                y_pred = predict(k, test_feature, train_feature, train_labels)
                y_pred = np.array(y_pred)
                y_pred = y_pred.reshape((-1,1))
                # calculate the accuracy
                accuracy = np.mean(y_pred == test_labels)
                print ("k: ", k, "Accuracy:", accuracy)
                accuracies.append(accuracy)

            # plot k vs accuracy
            plt.scatter(ks, accuracies)
            plt.suptitle("k-Nearest Neighbours")
            plt.title("MNIST dataset")
            plt.xlabel('Value of k')
            plt.ylabel('Accuracy obtained')
            plt.show()

        # datasets
```

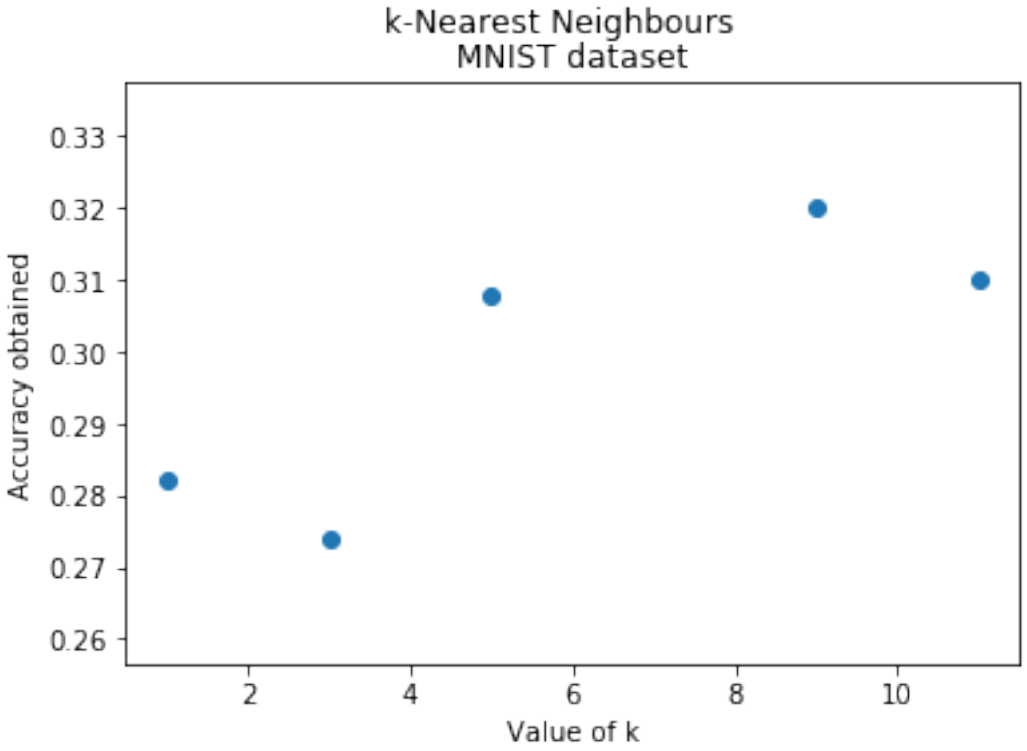
```
train_labels = train[:,[0]].astype(int)
test_labels = test[:,[0]].astype(int)
train_feature = train[:,1:]
test_feature = test[:,1:]

print("Dataset=MNIST, Feature Vector=Image pixels, Metric=Eucledian Distance")
result()

# histogram features
train_feature,test_feature = features(train_feature,test_feature)
print("Dataset=MNIST, Feature Vector=Histogram of Image, Metric=Eucledian Distance")
result()
```

```
Dataset=MNIST, Feature Vector=Image pixels, Metric=Eucledian Distance
k:  1 Accuracy: 0.906
k:  3 Accuracy: 0.918
k:  5 Accuracy: 0.91
k:  9 Accuracy: 0.898
k:  11 Accuracy: 0.876
```




```
Dataset=MNIST, Feature Vector=Histogram of Image, Metric=Eucledian Distance
k:  1 Accuracy: 0.282
```

```
k:  3 Accuracy: 0.274
k:  5 Accuracy: 0.308
k:  9 Accuracy: 0.32
k:  11 Accuracy: 0.31
```



The above results show that the pixel values when used as feature vector yield higher accuracies compared to choosing histogram of image as feature vector

0.1.2 Case II: CIFAR10 dataset

CIFAR10 contains 10 object classes. In both training as well as in test data each row stores a 32x32 color image. The first 1024 entries contain the red channel values, the next 1024 the green, and the final 1024 the blue.

```
In [35]: from scipy.io import loadmat
         import numpy as np
         import matplotlib.pyplot as plt
         import cv2
         from scipy.spatial.distance import cdist

         # load train data
         train = loadmat('CIFAR10_Train.mat')
         train_labels = train['CIFAR10_Train_Labels']
```

```
        train = train['CIFAR10_Train_Data']
        print("CIFAR10 train dataset size:",train.shape)

        # load test data
        test = loadmat('CIFAR10_Test.mat')
        test_labels = test['CIFAR10_Test_Labels']
        test = test['CIFAR10_Test_Data']
        print("CIFAR10 test dataset size:",test.shape)
        print("testlbl",test_labels.shape)

        # print(test_labels.shape)
        print("Visualizing the CIFAR10 dataset")
        fig=plt.figure(figsize=(8, 8))
        columns = 5
        rows = 5
        for i in range(1, columns*rows +1):
            img=train[i][0:1024].reshape((32, 32))
            fig.add_subplot(rows, columns, i)
            plt.imshow(img,cmap='gray')
        plt.show()
```

```
CIFAR10 train dataset size: (5000, 3072)
CIFAR10 test dataset size: (500, 3072)
testlbl (500, 1)
Visualizing the CIFAR10 dataset
```

Creating funtions for distance calculation and feature extraction

```
In [56]: # returns euclidean_distance vector
         def euclidean_distance(Xt,X):
             return cdist(Xt, X)

         # returns ncc distance vector
         def ncc(Xt,X):
             return np.dot(Xt,np.transpose(X))/(np.linalg.norm(Xt)*np.linalg.norm(X))

         # return histogram feature from the images (RGB channels)
         def features(train,test):
             # extract feature from train data
             train_feature = np.zeros((5000, 768))
             for j in range(train.shape[0]):
```

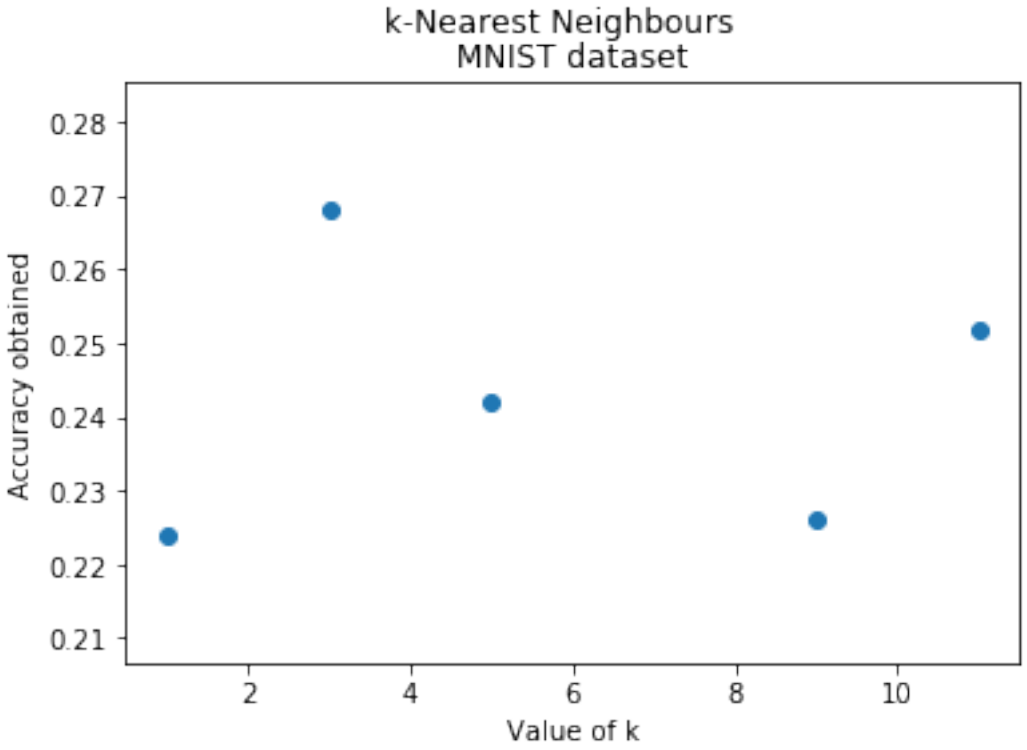
```
            feature1 = cv2.calcHist([train[j][:1024]], [0], None, [256], [0, 256])
            feature2 = cv2.calcHist([train[j][1024:2048]], [0], None, [256], [0, 256])
            feature3 = cv2.calcHist([train[j][2048:]], [0], None, [256], [0, 256])
            feature = np.concatenate((feature1, feature2,feature3), axis=0)
            train_feature[j]=feature.reshape((1,768))

        # extract feature from test data
        test_feature = np.zeros((500, 768))
        for j in range(test.shape[0]):
            feature1 = cv2.calcHist([test[j][:1024]], [0], None, [256], [0, 256])
            feature2 = cv2.calcHist([test[j][1024:2048]], [0], None, [256], [0, 256])
            feature3 = cv2.calcHist([test[j][2048:]], [0], None, [256], [0, 256])
            feature = np.concatenate((feature1, feature2,feature3), axis=0)
            test_feature[j]=feature.reshape((1,768))
        return train_feature,test_feature
```

Prediction and accuracy calculation

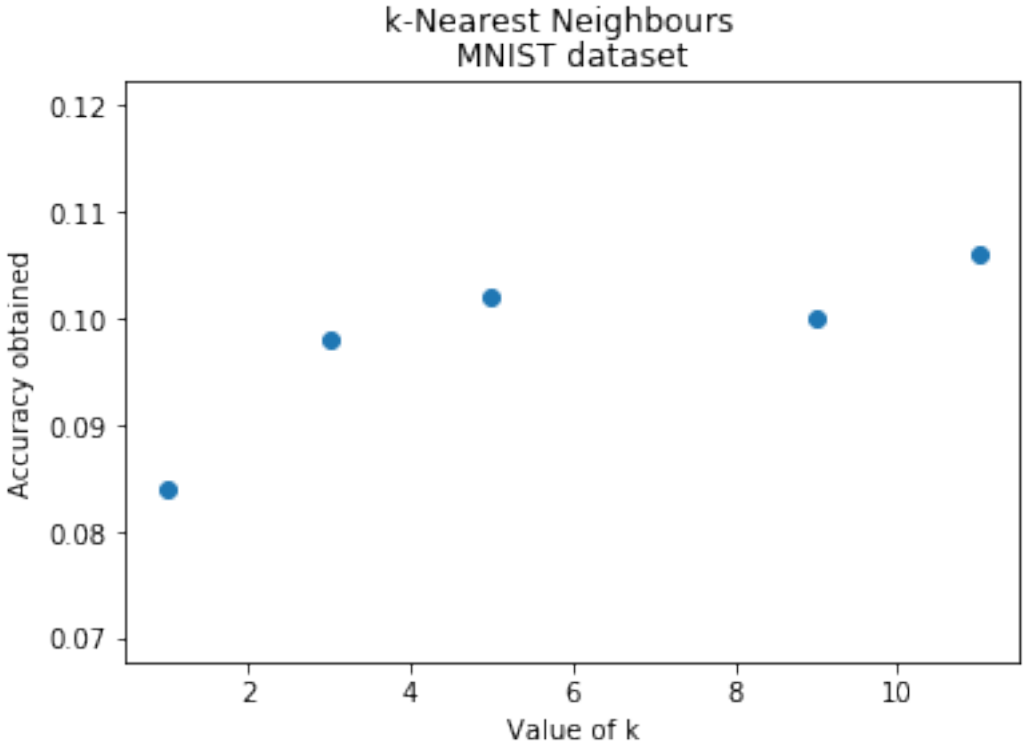
```
In [57]: def predict(meteric,k, Xt, X, y):
        # calculate distance
        if meteric=="ncc":
            distance = ncc(Xt, X)
        elif meteric=="Eucledian":
            distance = euclidean_distance(Xt, X)

        # Computing indices of k nearest neighbours of test image
        idx = np.argsort(distance)[:, :k]

        # Taking majority vote among the labels of knn
        y_pred = []
        for i in range(Xt.shape[0]):
            lab = y[idx[i]]
            sets, cnts = np.unique(lab, return_counts=True)
            y_pred.append(sets[np.argmax(cnts, axis = 0)])
        return y_pred

    def result(meteric):
        accuracies = []
        ks = [1,3,5,9,11]
        for k in ks:
            y_pred = predict(meteric,k, test_feature, train_feature, train_labels)
            y_pred = np.array(y_pred)
            y_pred = y_pred.reshape((-1,1))
            # calculate the accuracy
            accuracy = np.mean(y_pred == test_labels)
            print ("k: ", k, "Accuracy:", accuracy)
            accuracies.append(accuracy)
```

```
            # plot k vs accuracy
            plt.scatter(ks, accuracies)
            plt.suptitle("k-Nearest Neighbours")
            plt.title("MNIST dataset")
            plt.xlabel('Value of k')
            plt.ylabel('Accuracy obtained')
            plt.show()

        # extract histogram features
        train_feature,test_feature = features(train,test)

        print("Dataset=CIFAR10, Feature Vector=Histogram of Image, Metric=Eucledian Distance")
        meteric="Eucledian"
        result(meteric)

        print("Dataset=CIFAR10, Feature Vector=Histogram of Image, Metric=NCC")
        meteric="ncc"
        result(meteric)
```

```
Dataset=CIFAR10, Feature Vector=Histogram of Image, Metric=Eucledian Distance
k:  1 Accuracy: 0.224
k:  3 Accuracy: 0.268
k:  5 Accuracy: 0.242
k:  9 Accuracy: 0.226
k:  11 Accuracy: 0.252
```



```
Dataset=CIFAR10, Feature Vector=Histogram of Image, Metric=NCC
k:  1 Accuracy: 0.084
k:  3 Accuracy: 0.098
k:  5 Accuracy: 0.102
k:  9 Accuracy: 0.1
k:  11 Accuracy: 0.106
```



The accuracies for the CIFAR10 dataset are higher for the Euclidian meteric compared to the NCC meteric. Overall the kNN classification is unable to provide high (and usable) accuracies for classification.

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