Assignmnet10

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1 Assignment10

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1.0.3 GitHub : https://github.com/ChoiBowon/Assignment

```
In [3]: import matplotlib.pyplot as plt
        import numpy as np
        from scipy import signal
```

```
In [4]: file_data_train = "mnist_train.csv"
        file_data_test  = "mnist_test.csv"

        h_data_train    = open(file_data_train, "r")
        h_data_test     = open(file_data_test, "r")

        data_train      = h_data_train.readlines() #train data
        data_test       = h_data_test.readlines() #test data

        h_data_train.close()
        h_data_test.close()
```

```
In [5]: size_row    = 28    # height of the image
        size_col    = 28    # width of the image

        num_train   = len(data_train)    # number of training images
        num_test    = len(data_test)     # number of testing images
```

```
In [6]: #
        # normalize the values of the input data to be [0, 1]
        #
        def normalize(data):

            data_normalized = (data - min(data)) / (max(data) - min(data))

            return(data_normalized)
```

```
In [7]: #
        # example of distance function between two vectors x and y
        #
        def distance(x, y):

            d = (x - y) ** 2
            s = np.sum(d)
            # r = np.sqrt(s)

            return(s)
```

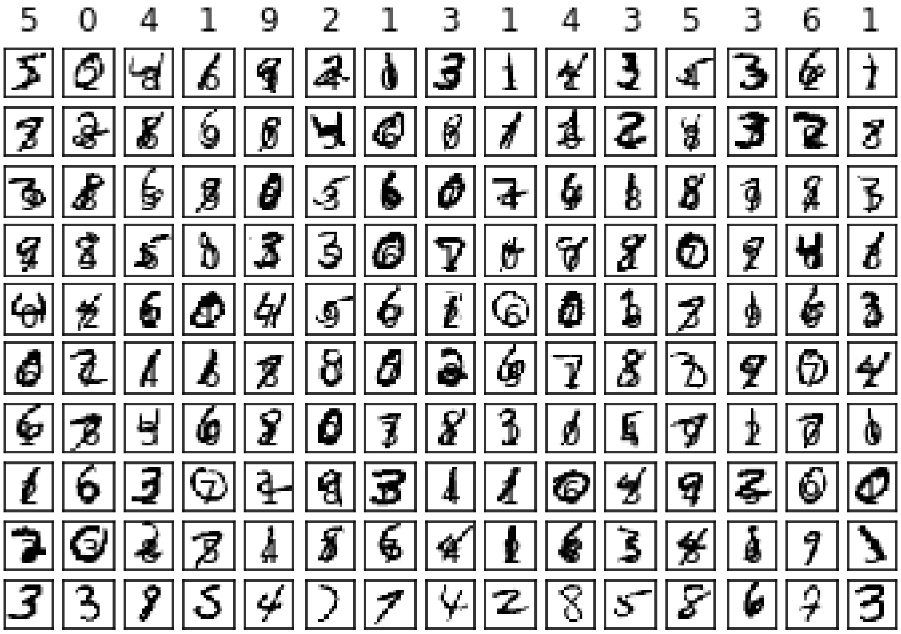
```
In [8]: #
        # make a matrix each column of which represents an images in a vector form
        #
        list_image_train    = np.empty((size_row * size_col, num_train), dtype=float) # train
        list_label_train    = np.empty(num_train, dtype=int) # train data label

        list_image_test     = np.empty((size_row * size_col, num_test), dtype=float) #  test d
        list_label_test     = np.empty(num_test, dtype=int) # test data label

        count = 0
```

```
In [9]: for line in data_train:  #data train = train data

            line_data   = line.split(',')
            label       = line_data[0]
            im_vector   = np.asfarray(line_data[1:])
            im_vector   = normalize(im_vector)

            list_label_train[count]     = label
            list_image_train[:, count]  = im_vector

            count += 1

        count = 0
```

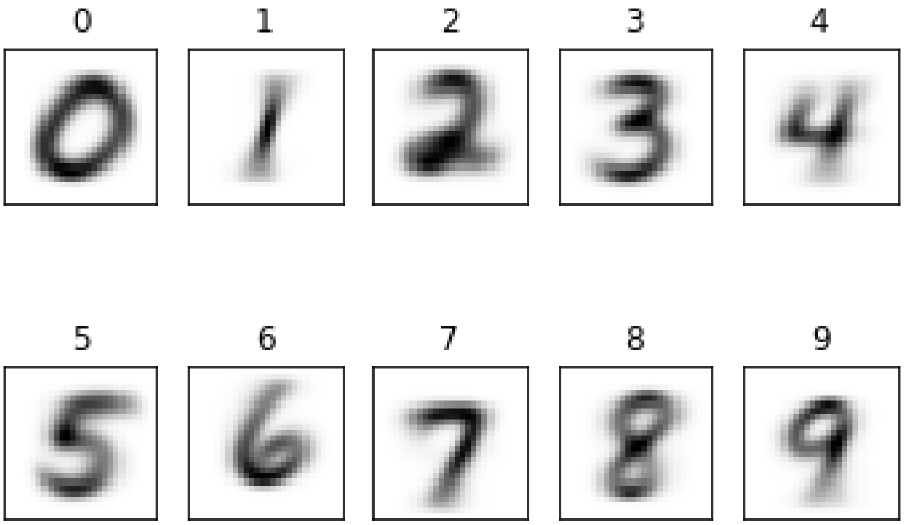
```
In [10]: for line in data_test:

             line_data   = line.split(',')
             label       = line_data[0]
             im_vector   = np.asfarray(line_data[1:])
             im_vector   = normalize(im_vector)

             list_label_test[count]      = label
             list_image_test[:, count]   = im_vector

             count += 1
```

```
In [11]: #
         # plot first 150 images out of 10,000 with their labels
```

```
#
f1 = plt.figure(1)

for i in range(150):

    label       = list_label_train[i]
    im_vector   = list_image_train[:, i]
    im_matrix   = im_vector.reshape((size_row, size_col))

    plt.subplot(10, 15, i+1)
    plt.title(label)
    plt.imshow(im_matrix, cmap='Greys', interpolation='None')

    frame   = plt.gca()
    frame.axes.get_xaxis().set_visible(False)
    frame.axes.get_yaxis().set_visible(False)
#plt.show()
```



```
In [12]: # plot the average image of all the images for each digit
         #
         f2 = plt.figure(2)

         im_average  = np.zeros((size_row * size_col, 10), dtype=float)
         im_count    = np.zeros(10, dtype=int)

         for i in range(num_train):
             im_average[:, list_label_train[i]] += list_image_train[:, i]
             im_count[list_label_train[i]] += 1

         for i in range(10):

             im_average[:, i] /= im_count[i]

             plt.subplot(2, 5, i+1)
             plt.title(i)
             plt.imshow(im_average[:,i].reshape((size_row, size_col)), cmap='Greys', interpola

             frame   = plt.gca()
             frame.axes.get_xaxis().set_visible(False)
             frame.axes.get_yaxis().set_visible(False)

         plt.show()
```



1.1 Define Matrix A, image featrue matrix

```
In [41]: def build_matrix(x):  #784,6000
             col = np.shape(x)[0]
             row = np.shape(x)[1]
             matrix = np.empty((row,col), dtype=float)
             for i in range(row):
                 for j in range(col):
                     matrix[i,j] = feature_func(j+1, x[:,i])
             return matrix
```

1.2 Define Featrue function

```
In [42]: def feature_func(i, x):
             return x[i-1]
```

1.3 Define function for random fecture vector p

```
In [43]: def randomfeaturevector(p):
             param = np.random.normal(0, 1, (p, 784))
             return param
```

1.4 Define b, y values

```
In [44]: def build_y(y):
             num = np.shape(y)[0]
             b = y.reshape((num, 1))
             condlist = [b==0, b!=0]
             choicelist = [1, -1]
             return np.select(condlist, choicelist)
```

1.5 Define fucntion to approximate model parameter

```
In [45]: def approx(matrix,b):
             if np.shape(b)[0] != 1:
                 num = np.shape(b)[0]
                 b = b.reshape((num, 1))
             feature = np.shape(matrix)[1]
             theta = np.zeros((feature,1), dtype=float)
             Q,R = np.linalg.qr(list_image_train.T)
             Rsol = np.matmul(Q.T, b)
             for i in range(feature):
                 n = feature - i
                 if R[n-1, n-1] == 0:
                     theta[n-1,0] = 0
                 else:
                     rthetasum = 0
                     for j in range(feature-n):
                         l = feature-j
                         rthetasum += R[n-1, l-1]*theta[l-1,0]
                     theta[n-1, 0] = (Rsol[n-1,0] - rthetasum)/R[n-1,n-1]
             return theta
```

1.6 Define F1 score function

```
In [46]: def F1score(list_TF):
             precision = list_TF[0] / (list_TF[0] + list_TF[3])
             recall = list_TF[0] / (list_TF[0] + list_TF[1])
             return 2*((precision * recall) / (precision + recall))
```

1.7 Plot model parameter

```
In [47]: def plot_theta(theta):
             data_normalized = (theta - min(theta)) / (max(theta) - min(theta))
             im_matrix = data_normalized.reshape((28,28))
             plt.imshow(im_matrix, cmap='Greys', interpolation='None')
             plt.title('plot model parameter')
             plt.show()
```

1.8 Define classifier

```
In [60]: def classifier(predict, b_test, Matrix_test):
             FN = []
             FP = []
             TN = []
             TP = []
             for i in range(0, len(predict)):
                 if(float(predict[i]) > 0):
                    if(int(b_test[i]) == 1):
                        TP.append(Matrix_test[i])
                    else:
                        FP.append(Matrix_test[i])
                 else:
                    if int(b_test[i]) == 1:
                        FN.append(Matrix_test[i])
                    else:
                        TN.append(Matrix_test[i])

             return FN,FP,TN,TP
```

1.9 Print F1 and confusion matrix

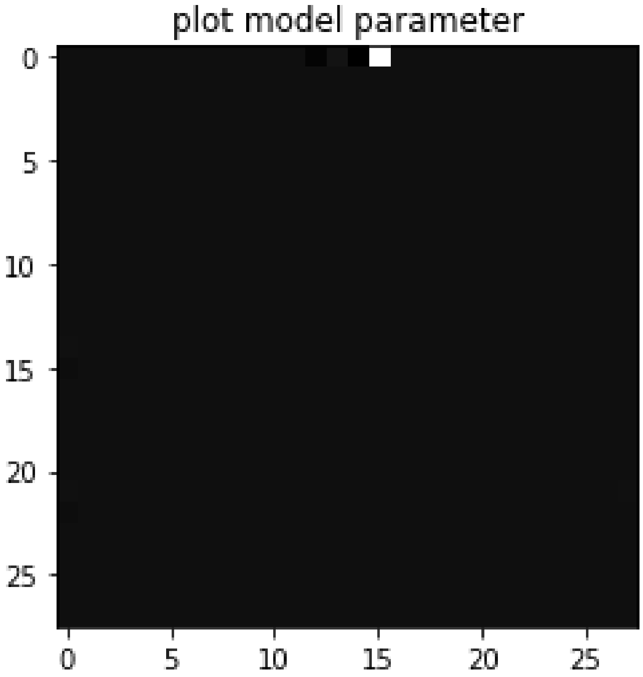
```
In [61]: from sklearn.linear_model import Perceptron
         from sklearn.metrics import f1_score
         from sklearn.metrics import confusion_matrix
         import pandas as pd
         import numpy as np

         tr = pd.read_csv("mnist_train.csv")
         ts = pd.read_csv("mnist_test.csv")
         tr = np.array(tr)
         ts = np.array(ts)
         tr_y, tr_x = np.split(tr,[1], axis = 1)
         ts_y, ts_x = np.split(ts,[1], axis = 1)

         def random_X(p):
             random = np.random.normal(0, 1, (2**p, 784))
             return random
```

```
def A(X, random):
    return np.dot(X, random.T)

top_y = np.zeros(ts_y.shape)
temp = 0
for i in range(2, 10):
    r_arr = random_X(i)
    tr_A = A(tr_x, r_arr)
    ts_A = A(ts_x, r_arr)
    pct = Perceptron()
    pct.fit(tr_A, tr_y)
    y_pred = pct.predict(ts_A)
    f1 = f1_score(ts_y, y_pred, labels=np.unique(y_pred), average = 'macro')
    print("f1 : " , f1)

    if f1 > temp:
        temp = f1
        top_y = y_pred

print("Confusion matrix")
print(confusion_matrix(ts_y, top_y))
```

```
/Users/choibowon/anaconda3/lib/python3.6/site-packages/sklearn/linear_model/stochastic_gradien
  "and default tol will be 1e-3." % type(self), FutureWarning)
/Users/choibowon/anaconda3/lib/python3.6/site-packages/sklearn/utils/validation.py:578: DataCo
  y = column_or_1d(y, warn=True)


f1 :  0.1441336937187336
f1 :  0.25973882953780614
f1 :  0.3719298913598522
f1 :  0.6404509721176298
f1 :  0.7071396327789007
f1 :  0.8251853163914451
f1 :  0.8609950678578964
f1 :  0.8646131440517429
Confusion matrix
[[ 915    0    3    4    0   10   18    2   25    3]
 [   0 1096    2    4    1    0    4    0   27    1]
 [   5   15  855   20    5    4   20    8   93    7]
 [   4    0   26  873    1   17    4    7   72    6]
 [   3    2    4    0  840    0   13    0   86   34]
 [  14    4    3   49    6  609   15    3  179   10]
 [   7    2    5    2    5   14  906    1   16    0]
 [   6   13   15    5   12    3    3  879   47   44]
 [   4    8    4   19    9   12    7    3  907    1]
 [   8    9    0   12   19    6    1   17  195  742]]
```

1.10 Train and predict

```
In [62]: Matrix_train = build_matrix(list_image_train)
         b_train = build_y(list_label_train)
         model_parameter = approx(Matrix_train, b_train)
         plot_theta(model_parameter)
         Matrix_test = build_matrix(list_image_test)
         b_test = build_y(list_label_test)
         predict = np.matmul(Matrix_test,model_parameter)
         FN,FP,TN,TP = classifier(predict, b_test, Matrix_test)
```



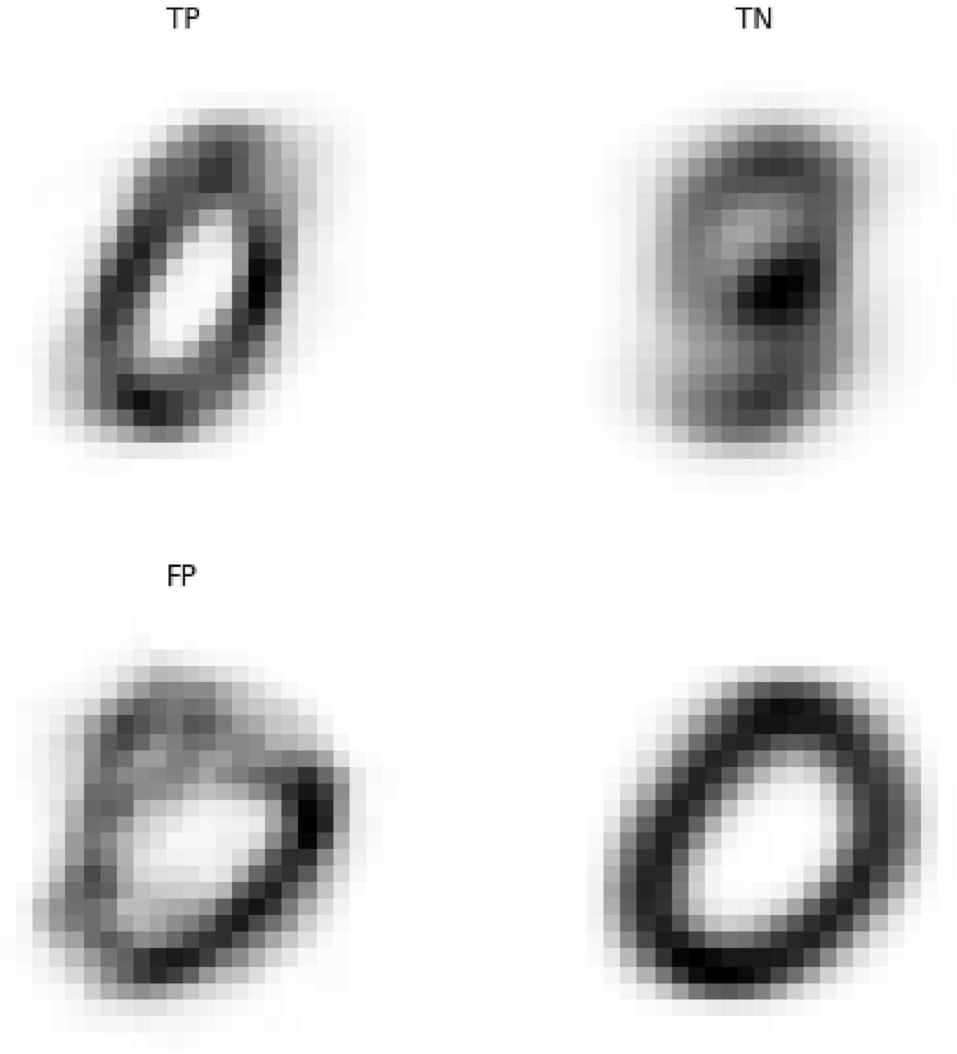
```
In [63]: def randmatrix(rand, Matrix_train):

             return np.dot(Matrix_train, rand.T)
```

1.11 Define function for getting average

```
In [64]: def average(x):
             x = np.mat(x)
             avg = np.mean(x, axis=0)

             return avg
```

1.12 Plot average TP, FP, TN, FN

```
In [65]: plt.figure(figsize=(8,8))

         im_average = np.zeros((size_row*size_col, 10), dtype=float)
         im_count = np.zeros(10, dtype=int)

         P1 = plt.subplot(2,2,1)
         P1.set_title('FN')
         im_average = average(FN)
         plt.imshow(im_average.reshape((size_row, size_col)), cmap='Greys', interpolation='None
         plt.axis('off')

         P2 = plt.subplot(2,2,2)
         P2.set_title('TN')
         im_average = average(TN)
         plt.imshow(im_average.reshape((size_row, size_col)), cmap='Greys', interpolation='None
         plt.axis('off')

         P3 = plt.subplot(2,2,3)
         P3.set_title('FP')
         im_average = average(FP)
         plt.imshow(im_average.reshape((size_row, size_col)), cmap='Greys', interpolation='None
         plt.axis('off')


         P4 = plt.subplot(2,2,4)
         P1.set_title('TP')
         im_average = average(TP)
         plt.imshow(im_average.reshape((size_row, size_col)), cmap='Greys', interpolation='None
         plt.axis('off')

         plt.show()
```


TP
TN
FP