Assignment08

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- Description: Binary-classfication using MNIST data
- github: https://github.com/mydream757/Computer_Vision

1. Import libraries

- import needed libraries.

```
In [1]: import matplotlib.pyplot as plt
        import numpy as np
        import numpy.linalg as lin
        from matplotlib.image import imread
```

2. Read data from CSV files

- get ready for using MNIST data

```
In [2]: 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()
        data_test       = h_data_test.readlines()

        h_data_train.close()
        h_data_test.close()

        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
```

3. Define functions

- the function of data normalizing

```
In [3]: # 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)
```

- the function of computing distance

```
In [4]: def distance(x, y):

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

4. Define classifier

- make containers which contain MNIST image data

```
In [5]: #make a matrix each column of which represents an images
        list_image_train    = np.empty((num_train, size_row * size_col), dtype=float)
        list_label_train    = np.empty(num_train, dtype=int)

        list_image_test     = np.empty((num_test, size_row * size_col), dtype=float)
        list_label_test     = np.empty(num_test, dtype=int)
```

- parse the data sets

```
In [6]: count = 0
        for line in data_train:

            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
        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
```

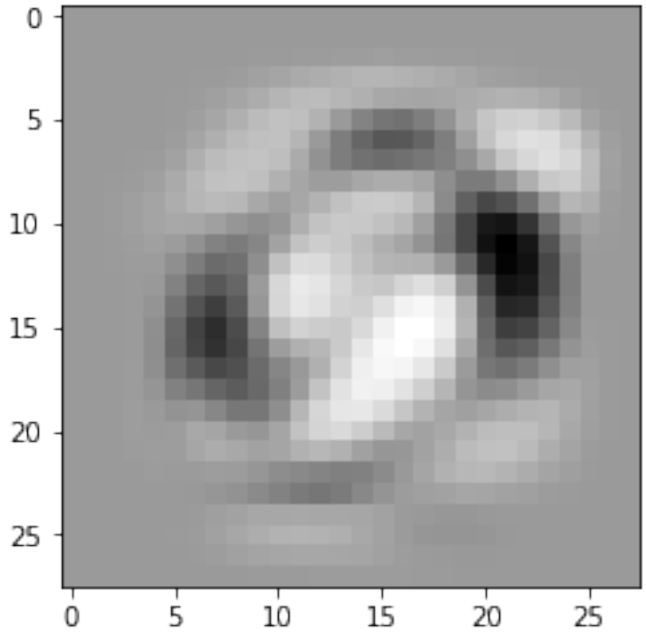
```
            list_image_test[count,:]  = im_vector

            count += 1
```

- compute average images of each digits and label 1 or -1

```
In [7]: im_average  = np.zeros((10, size_col*size_row), 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

        im_label = np.zeros((10,1), dtype=float)
        for i in range(10):
            im_average[i,:] /= im_count[i]
            #label = 0 : 1, others : -1
            if i==0:
                im_label[0,0] = 1
            else:
                im_label[i,0] = -1
```

- compute coefficient.

```
In [8]: #compute coefficient using average image vectors
        inverse = lin.pinv(im_average)
        coefficient = np.dot(inverse, im_label)

        #plot the coefficient image
        image_coeff = coefficient[:,0].reshape((size_row, size_col))
        plt.figure()
        plt.imshow(image_coeff, cmap='Greys', interpolation='None')
        plt.show()
```



5. Evaluate the classifier using the test data

- ready for test

```
In [9]: #Ready for test
        experiment_label_test = np.empty(num_test, dtype=int)
        experiment_average_test = np.zeros((4,size_row * size_col), dtype=float)
        experiment_count_test = np.zeros(4, dtype=int)
```

- label 1 or -1 to test data and check TP, FP, FN, TN

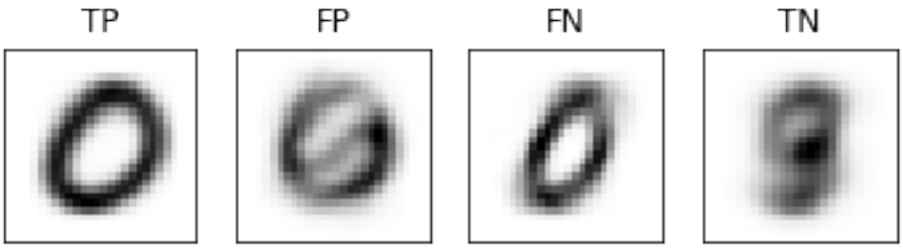
```
In [10]: #Evaluate my classifier using MNIST test set
         result = np.dot(list_image_test, coefficient)
         num = 0
         for i in range(result.size):
             #sign(f(x))
             if result[i] >= 0:
                 experiment_label_test[i] = 1
             else:
                 experiment_label_test[i] = -1
             #check TP, FP, TN, FN
             if experiment_label_test[i] == 1 and list_label_test[i] == 0:
                 num = 0 #then TP
             elif experiment_label_test[i] == 1 and list_label_test[i] !=0:
                 num = 1 #then FP
             elif experiment_label_test[i] == -1 and list_label_test[i] == 0:
```

```
            num = 2 #then FN
        elif experiment_label_test[i] == -1 and list_label_test[i] !=0:
            num = 3 #then TN
        experiment_average_test[num,:] += list_image_test[i,:]
        experiment_count_test[num] += 1
```

- plot the result

```
In [11]: plt.figure()
         for i in range(4):
             experiment_average_test[i, :] /= experiment_count_test[i]
             title = ['TP','FP','FN','TN']
             plt.subplot(1, 4, i+1)
             plt.title(title[i])
             plt.imshow(experiment_average_test[i,:].reshape((size_row, size_col)), cmap='Greys'

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

             print(title[i],': ',experiment_count_test[i])
         table = imread('Eval_table.png')
         plt.figure()
         plt.imshow(table)
         plt.show()
```

```
TP :  871
FP :  417
FN :  109
TN :  8603
```



	Original data label		
	Label = '0'	Label = '2,3,4...9'	
Sign = 1	TP = 871	FP = 417	Total Positive = 1288
Sign = -1	FN = 109	TN = 8603	Total negative = 8712
	Total L = '0' = 980	Total L = '2,3,4...9' = 9020	Grand total = 10000

- compute evaluations

```
In [12]: #print the evaluation
         print('Error rate: ',(experiment_count_test[1]+experiment_count_test[2])*100/num_test,'
         print('Precision: ', experiment_count_test[0]*100/(experiment_count_test[0]+experiment_
         print('Recall: ',experiment_count_test[0]*100/(experiment_count_test[0]+experiment_coun
         print('False positive rate: ',experiment_count_test[1]*100/(experiment_count_test[1]+ex
         print('Accuracy: ', (experiment_count_test[0]+experiment_count_test[3])*100/num_test,'%
         plt.show()

Error rate:  5.26 %
Precision:  67.62422360248448 %
Recall:  88.87755102040816 %
False positive rate:  4.623059866962306 %
Accuracy:  94.74 %
```