Assignment09

November 25, 2018

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- Description: Varing feature function and import MNIST 0 classifier
- 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]: # 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)
```

- the function of 'feature funtion'. this returns feature upto max P.

```
In [5]: # return the feature function vectors upto Max P
        def featureFun(maxP):
            #feature function: numpy.random.normal
            f = np.empty((size_col*size_row,maxP),dtype=float)
            for i in range(maxP):
                f[:,i]=np.random.normal(0,1,size_col*size_row)
            #result = np.dot(f.T,x.T)
            return f
```

4. Ready for test

- make containers which contain MNIST image data

```
In [6]: #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 [7]: #parse the data sets
        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 [8]: 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
```

- 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)
        result_average_test = np.zeros((4,size_row * size_col), dtype=float)
        result_count_test = np.zeros(4, dtype=int)
        Final = 0
        FinalP = 0
        #P can't be over MaxP
        maxP = pow(2, 14)
        print("MaxP: ",maxP)
        #compute feature function of MaxP
        f = featureFun(maxP)
```

```
MaxP:  16384
```

5. Test and Find the best p

- find the rough P

```
In [10]: #compute coefficient using average image vectors and feature function
         for i in range(13):
             print(i,"iteration")
             score = 0
             #initialize containers
             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)

             #set different parameter, P
             p = pow(2,i)
             print("P: ",p)
             fx = np.dot(f[:,:p-1].T,im_average.T)
             inverse = lin.pinv(fx.T)
             coefficient = np.dot(inverse, im_label)

             #Evaluate my classifier using MNIST test set
             result = np.dot(np.dot(f[:,:p-1].T, list_image_test.T).T, coefficient)
             num = 0
             for k in range(result.size):
                 #sign(f(x))
                 if result[k] >= 0:
                     experiment_label_test[k] = 1
                 else:
                     experiment_label_test[k] = -1
                 #check TP, FP, TN, FN
                 if experiment_label_test[k] == 1 and list_label_test[k] == 0:
                     num = 0 #then TP
                 elif experiment_label_test[k] == 1 and list_label_test[k] !=0:
                     num = 1 #then FP
                 elif experiment_label_test[k] == -1 and list_label_test[k] == 0:
                     num = 2 #then FN
                 elif experiment_label_test[k] == -1 and list_label_test[k] !=0:
                     num = 3 #then TN
                 experiment_average_test[num,:] += list_image_test[k,:]
                 experiment_count_test[num] += 1

             for j in range(4):
                 if experiment_count_test[j]!=0:
                     experiment_average_test[j, :] /= experiment_count_test[j]

             precision = experiment_count_test[0]*100/(experiment_count_test[0]+experiment_count
             recall = experiment_count_test[0]*100/(experiment_count_test[0]+experiment_count_te
             #get the score
             score = (2*precision*recall)/(precision+recall)
             print("score: ",score)
             if score > Final:
                 FinalP = p
                 Final = score
                 result_average_test = experiment_average_test
                 result_count_test = experiment_count_test

             print("best score: ",Final)
```

```
0 iteration
P:  1
score:  17.85063752276867
best score:  17.85063752276867
1 iteration
P:  2
score:  2.253521126760563
best score:  17.85063752276867
2 iteration
P:  4
score:  4.5668233713901945
best score:  17.85063752276867
3 iteration
P:  8
score:  38.31376734258271
best score:  38.31376734258271
4 iteration
P:  16
score:  41.00440072482527
best score:  41.00440072482527
5 iteration
P:  32
score:  61.00037608123354
best score:  61.00037608123354
6 iteration
P:  64
score:  67.49072929542646
best score:  67.49072929542646
7 iteration
P:  128
score:  72.38014425116674
best score:  72.38014425116674
8 iteration
```

```
P:  256
score:  74.39024390243904
best score:  74.39024390243904
9 iteration
P:  512
score:  75.79225352112677
best score:  75.79225352112677
10 iteration
P:  1024
score:  75.92592592592591
best score:  75.92592592592591
11 iteration
P:  2048
score:  76.11159546643417
best score:  76.11159546643417
12 iteration
P:  4096
score:  76.09457092819615
best score:  76.11159546643417
```

- vary parameter p with standard deviation = 1

```
In [11]: #varing p with standard deviation = 1
         k=0
         incremental = 1
         p = FinalP
         stopChecker = 0
         for r in range(100):
             print(r," iteration")
             #set different parameter, P
             p = p + incremental
             score = 0
             #initialize containers
             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)

             print("P: ",p)
             fx = np.dot(f[:,:p-1].T,im_average.T)
             inverse = lin.pinv(fx.T)
             coefficient = np.dot(inverse, im_label)

             #Evaluate my classifier using MNIST test set
             result = np.dot(np.dot(f[:,:p-1].T, list_image_test.T).T, coefficient)
             num = 0
             for k in range(result.size):
                 #sign(f(x))
```

```
                if result[k] >= 0:
                    experiment_label_test[k] = 1
                else:
                    experiment_label_test[k] = -1
                #check TP, FP, TN, FN
                if experiment_label_test[k] == 1 and list_label_test[k] == 0:
                    num = 0 #then TP
                elif experiment_label_test[k] == 1 and list_label_test[k] !=0:
                    num = 1 #then FP
                elif experiment_label_test[k] == -1 and list_label_test[k] == 0:
                    num = 2 #then FN
                elif experiment_label_test[k] == -1 and list_label_test[k] !=0:
                    num = 3 #then TN
                experiment_average_test[num,:] += list_image_test[k,:]
                experiment_count_test[num] += 1

            for j in range(4):
                experiment_average_test[j, :] /= experiment_count_test[j]
            precision = experiment_count_test[0]*100/(experiment_count_test[0]+experiment_count
            recall = experiment_count_test[0]*100/(experiment_count_test[0]+experiment_count_te
            #get the score
            score = (2*precision*recall)/(precision+recall)
            print("score: ",score)
            if Final == score:
                stopChecker += 1

            elif score > Final:
                FinalP = p
                Final = score
                result_average_test = experiment_average_test
                result_count_test = experiment_count_test
            #change incremental direction
            elif Final>score:
                incremental *= -1
            print("best score: ",Final)

            #loop stop condition
            if stopChecker == 3:
                break

        print("P of the best score: ",FinalP)
        print("The best score(F1): ",Final)
```

```
0  iteration
P:  2049
score:  76.11159546643417
best score:  76.11159546643417
1  iteration
```

```
P:  2050
score:  76.15720524017469
best score:  76.15720524017469
2  iteration
P:  2051
score:  76.09075043630017
best score:  76.15720524017469
3  iteration
P:  2050
score:  76.15720524017469
best score:  76.15720524017469
4  iteration
P:  2049
score:  76.11159546643417
best score:  76.15720524017469
5  iteration
P:  2050
score:  76.15720524017469
best score:  76.15720524017469
P of the best score:  2050
The best score(F1):  76.15720524017469
```

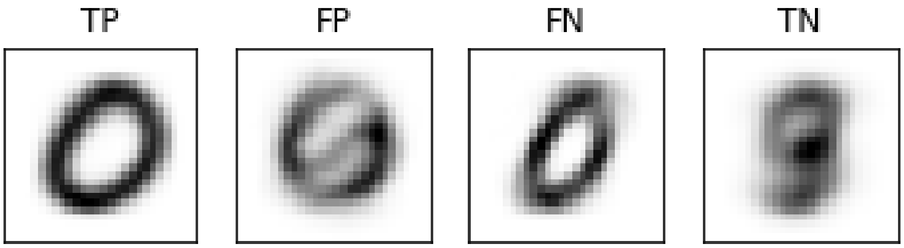
- plot the TP,FP,FN,TN

```
In [12]: #plot the TP,FP,TN,FN
         plt.figure()
         for i in range(4):
             result_average_test[i, :] /= result_count_test[i]
             title = ['TP','FP','FN','TN']
             plt.subplot(1, 4, i+1)
             plt.title(title[i])
             plt.imshow(result_average_test[i,:].reshape((size_row, size_col)), cmap='Greys', in

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

             print(title[i],': ',result_count_test[i])
         plt.show()
```

```
TP :  872
FP :  438
FN :  108
TN :  8582
```


TP
FP
FN
TN