Assignment 10

과제 정의

Build a binary classifier for each digit against all the other digits at MNIST dataset.

Let x = (x_1, x_2, ... , x_m) be a vector representing an image in the dataset.

The prediction function f_d(x; w) is defined by the linear combination of data (1, x) and the model parameter w for each digit d : f_d(x; w) = w_0 *1* + *w_1* x_1 + w_2 *x_2* + ... + *w_m* x_m where w = (w_0, w_1, ... , w_m)

The prediction function f_d(x; w) should have the following values: f_d(x; w) = +1 if label(x) = d f_d(x; w) = -1 if label(x) is not d

The optimal model parameter w is obtained by minimizing the following objective function for each digit d : \sum_i (f_d(x^(i); w) - y^(i))^2

and the label of input x is given by:

argmax_d f_d(x; w)

1. Compute an optimal model parameter using the training dataset for each classifier f_d(x, w)
2. Compute (1) true positive rate, (2) error rate using (1) training dataset and (2) testing dataset.

모듈 정의

In [44]:

```
import numpy as np
import collections
import matplotlib.pyplot as plt
```

1. Compute an optimal model parameter using the training dataset for each classifier f_d(x, w)

In [45]:

```
file_data   = "mnist_train.csv"
handle_file = open(file_data, "r")
data        = handle_file.readlines()
handle_file.close()

size_row    = 28    # height of the image
size_col    = 28    # width of the image

num_image   = len(data)
count       = 0     # count for the number of images


def normalize(data):
    data_normalized = (data - min(data)) / (max(data) - min(data))
    return(data_normalized)


# list_label  = np.empty(num_image, dtype=int)
list_label = []
int_data = []
int_data_y = {0:[],1:[],2:[],3:[],4:[],5:[],6:[],7:[],8:[],9:[]}
X = dict()
for line in data:
    line_data   = line.split(',')
    label       = line_data[0]
    im_vector   = np.asfarray(line_data[1:])
    im_vector   = normalize(im_vector)
    im_vector = np.insert(im_vector, 0, 1)
    int_data.append(im_vector)
    list_label.append(int(label))
    for x in range(0,10):
        if x == int(label):
            int_data_y[x].append(1.0)
        else:
            int_data_y[x].append(-1.0);
    count += 1

xn = np.array(int_data,dtype=float)
for i in range(0,10):
    X[i] = np.dot(np.linalg.pinv(xn) , np.array(int_data_y[i],dtype=float))
print(X)
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```

2. Compute true positive rate, error rate using training dataset

- 예측한 label (argmax)과 실제 이미지를 비교. (50 이하만)

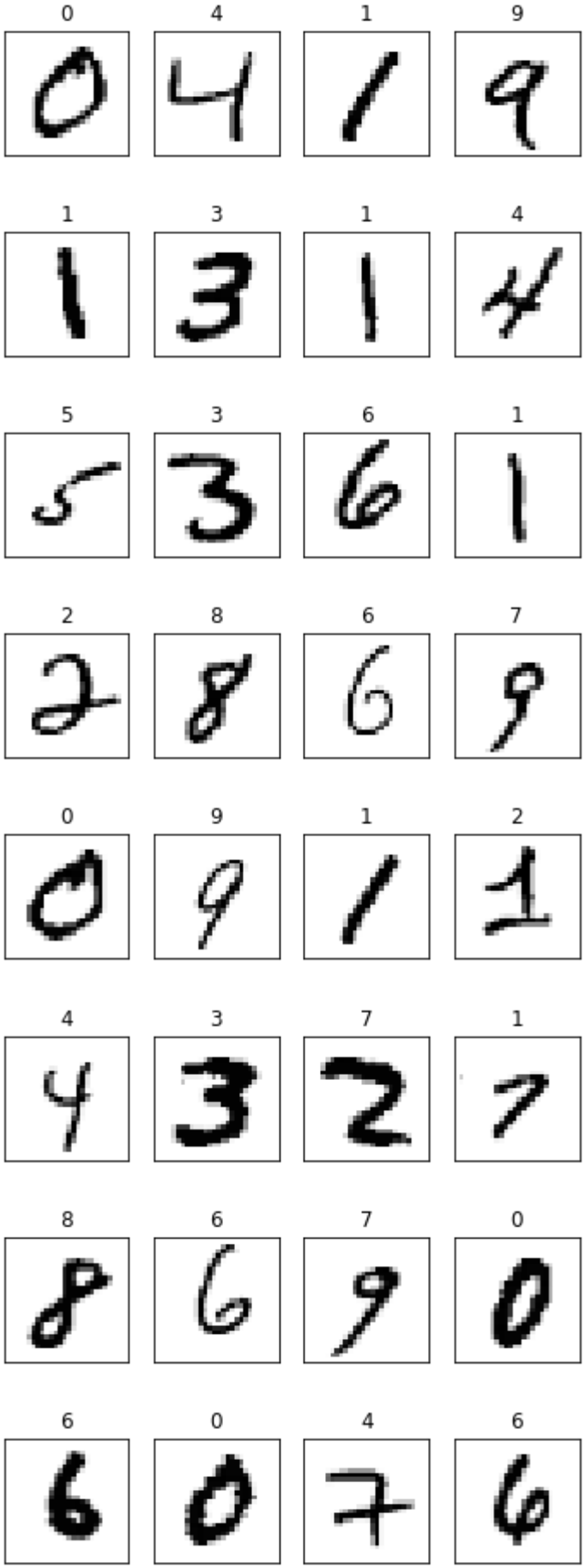
In [46]:

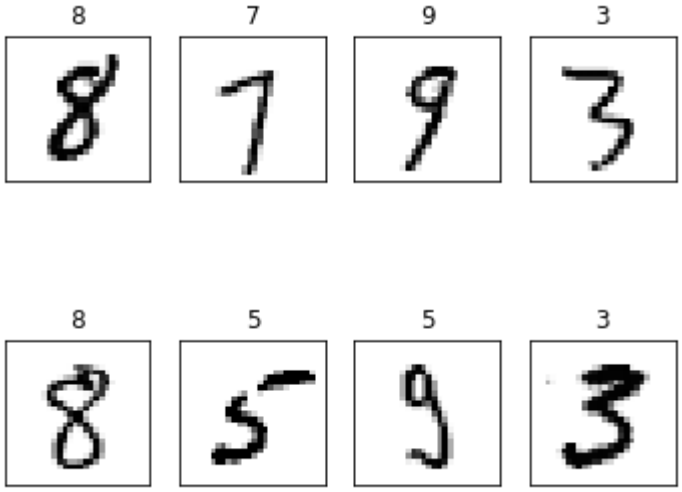
```
count = 0
tp = 0
error = 0
for x in range(len(xn)):
    f1 = plt.figure(1)
    argmax = []
    for i in range(0,10):
        argmax.append(np.dot(xn[x],X[i]))
    label       = argmax.index(max(argmax))
    if x < 50:
        im_vector   =  np.delete(xn[x], 0)
        im_matrix   = im_vector.reshape((size_row, size_col))
        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)

        count = count + 1

        if count == 1:
            plt.subplot(1, 4, 1)
        elif count == 2:
            plt.subplot(1, 4, 2)
        elif count == 3:
            plt.subplot(1, 4, 3)
        elif count == 4:
            plt.subplot(1, 4, 4)
        elif count == 5:
            plt.show()
            count = 0

    if list_label[x] == label:
        tp = tp + 1
    else:
        error = error + 1
```


0 4 1 9
1 3 1 4
5 3 6 1
2 8 6 7
0 9 1 2
4 3 7 1
8 6 7 0
6 0 4 6



In [47]:

```
print("true positive rate :" + str(tp/num_image))
print("error rate : " + str(error/num_image))
```

```
true positive rate :0.8577166666666667
error rate : 0.14228333333333334
```

2. Compute true positive rate, error rate using testing dataset

- 예측한 label (argmax)과 실제 이미지를 비교. (50 이하만)

In [48]:

```
file_data   = "mnist_test.csv"
handle_file = open(file_data, "r")
data        = handle_file.readlines()
handle_file.close()

size_row    = 28    # height of the image
size_col    = 28    # width of the image

num_image   = len(data)
count       = 0     # count for the number of images


def normalize(data):
    data_normalized = (data - min(data)) / (max(data) - min(data))
    return(data_normalized)


# list_label  = np.empty(num_image, dtype=int)
list_label = []
int_data = []
for line in data:
    line_data   = line.split(',')
    label       = line_data[0]
    im_vector   = np.asfarray(line_data[1:])
    im_vector   = normalize(im_vector)
    im_vector = np.insert(im_vector, 0, 1)
    int_data.append(im_vector)
    list_label.append(int(label))

xn = np.array(int_data,dtype=float)
```

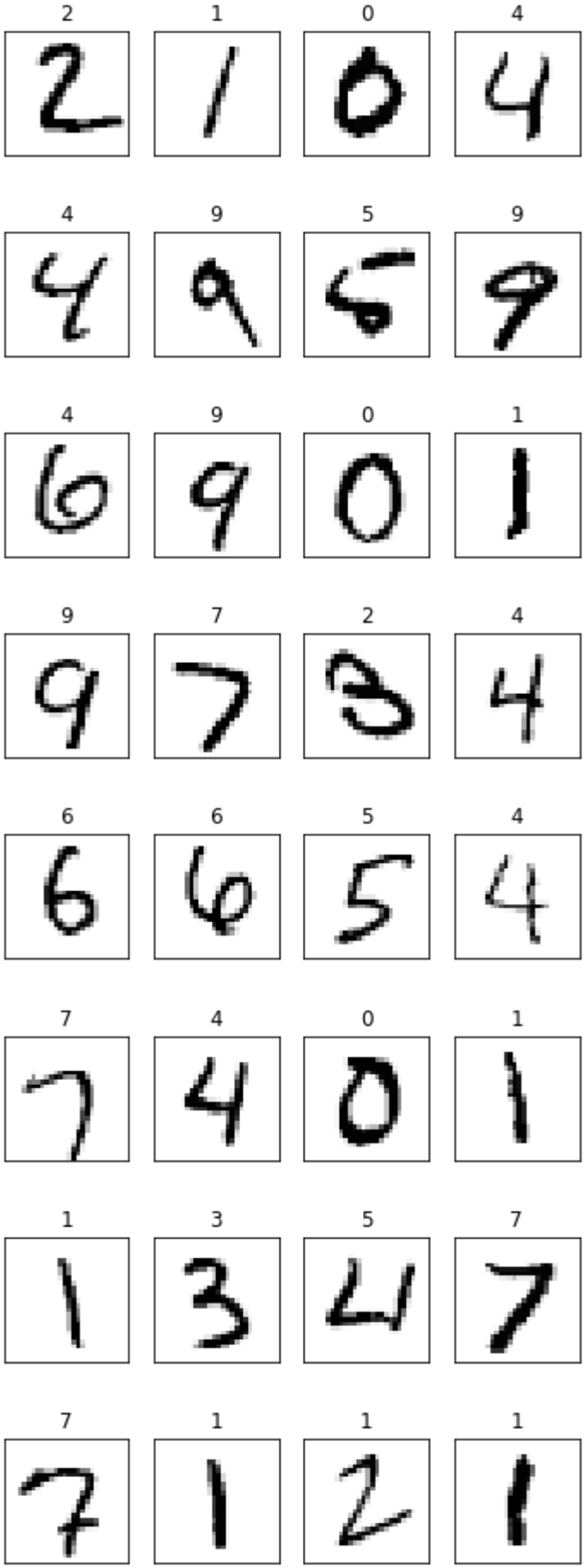
In [49]:

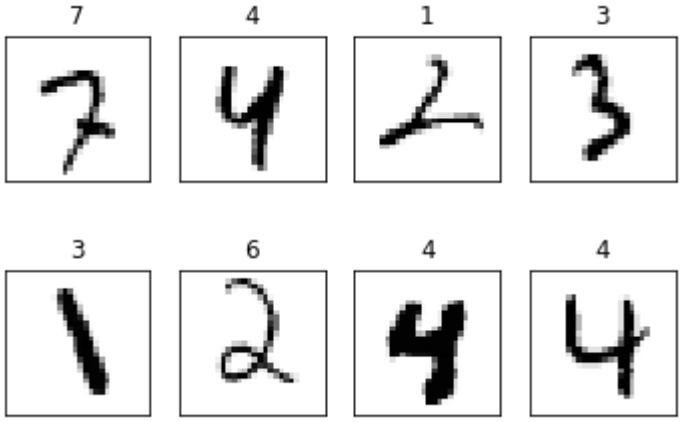
```
count = 0
tp = 0
error = 0
for x in range(len(xn)):
    f1 = plt.figure(1)
    argmax = []
    for i in range(0,10):
        argmax.append(np.dot(xn[x],X[i]))
    label       = argmax.index(max(argmax))
    if x < 50:
        im_vector   =  np.delete(xn[x], 0)
        im_matrix   = im_vector.reshape((size_row, size_col))
        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)

        count = count + 1

        if count == 1:
            plt.subplot(1, 4, 1)
        elif count == 2:
            plt.subplot(1, 4, 2)
        elif count == 3:
            plt.subplot(1, 4, 3)
        elif count == 4:
            plt.subplot(1, 4, 4)
        elif count == 5:
            plt.show()
            count = 0

    if list_label[x] == label:
        tp = tp + 1
    else:
        error = error + 1
```


2 1 0 4
4 9 5 9
4 9 0 1
9 7 2 4
6 6 5 4
7 4 0 1
1 3 5 7
7 1 1 1



In [50]:

```
print("true positive rate :" + str(tp/num_image))
print("error rate : " + str(error/num_image))
```

```
true positive rate :0.8602
error rate : 0.1398
```