Assignment4

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1 Information

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Project : *K − means Clustering*

2 import library

```
In [1]: from collections import Counter
        from collections import OrderedDict
        import matplotlib.pyplot as plt
        import numpy as np
        import random as rd
```

3 Load file

```
In [2]: file_data1  = "mnist_train.csv"
        file_data2 = "mnist_test.csv"
        handle_file1= open(file_data1, "r")
        train_data         = handle_file1.readlines()
        handle_file2=open(file_data2, "r")
        test_data          = handle_file2.readlines()
        handle_file1.close()
        handle_file2.close()
```

4 Global parameter

```
In [3]: size_row = 28        # height of the image
        size_col  = 28         # width of the image
        num_train = len(train_data)
        num_test = len(test_data)
        count          = 0     # count for the number of images
        cluster  = 0;

        pre_list_label  = np.empty(num_train, dtype=int)
```

```
    cluster_label = np.empty(num_train, dtype=int)

    train_image  = np.empty((size_row * size_col, num_train), dtype=float)
    train_label  = np.empty(num_train, dtype=int)

    test_image  = np.empty((size_row * size_col, num_test), dtype=float)
    test_label = np.empty(num_test, dtype=int)
```

5 Function: normalize the values of the input data to be [0, 1]

```
In [4]: def normalize(data):

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

            return(data_normalized)
```

6 Function: Distance between two vectors x and y

```
In [5]: def distance(x, y):

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

            return(s)
```

7 Function: Visualizer

```
In [6]: def visualizer(k, data, data_label):
            f1 = plt.figure(1)
            for i in range(k):

                im_vector   = data[:, i]
                im_matrix   = im_vector.reshape((size_row, size_col))

                plt.subplot(1, k, i+1)
                plt.title(data_label[i])
                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()
```

8 Function: Initialize centroid

```
In [7]: def initialize_centroid(k, data, data_label, num_data):
            centroid_label = np.empty(num_data, dtype=int)

            # clustering
            for i in range(num_data):
                label = rd.randint(1, k) - 1
                centroid_label[i] = label

            return(centroid_label)
```

9 Function: Calculate centroid

```
In [8]: def calculate_centroid(k, train_data, train_label, centroid_label, num_train):

            centroid = np.zeros((size_row * size_col, k), dtype=float)
            count = np.zeros(k,dtype=int)

            # Create centroid image
            for i in centroid_label:
                centroid[:,i] = centroid[:,i] + train_data[:, sum(count)]
                count[i] += 1

            for i in range(k):
                if (count[i] != 0):
                    centroid[:, i] /= count[i]
                    centroid[:, i] = normalize(centroid[:, i])

            return(centroid)
```

10 Function: Clustering data

```
In [9]: def clustering(k, train_image, centroid, num_train):
            cluster_label = np.empty(num_train,dtype=int)
            dist = np.empty(k, dtype=float)

            for i in range(num_train):
                for j in range(k):
                    dist[j] = distance(train_image[:, i], centroid[:, j])
                cluster_label[i] = np.argmin(dist)

            return cluster_label
```

11 Function: Find label

```
In [10]: def labeling(k, cluster_label, data_label, num_data):
             real_label = np.zeros(k, dtype=int)
             label_check = np.zeros((k, 10), dtype=int)
             for i in range(num_data):
                 label_check[cluster_label[i], data_label[i]] += 1

             for i in range(k):
                 real_label[i] = np.argmax(label_check[i,:])

             return real_label
```

12 Function: K Means algorithms

```
In [11]: def k_means(k, train_data, train_label, num_train):
             iteration = 0
             energy = []
             train_accuracy = []
             test_accuracy = []
             real_label = np.empty(k, dtype=int)

             previous_label = np.zeros(num_train, dtype=int)
             centroid_label = initialize_centroid(k, train_data, train_label, num_train)

             while (~np.all(previous_label == centroid_label)):
                 iteration+=1

                 centroid = calculate_centroid(k, train_data, train_label, centroid_label, num

                 # check traaining energy
                 energy.append(calculate_energy(train_data, num_train, centroid, centroid_label

                 # check training accuracy
                 train_accuracy.append(calculate_accuracy(k, centroid_label, train_label, num_t

                 # check testing accuracy
                 testing_label = clustering(k, test_image, centroid, num_test)
                 test_accuracy.append(calculate_accuracy(k, testing_label, test_label, num_test

                 previous_label = centroid_label
                 centroid_label = clustering(k, train_image, centroid, num_train)


             # Visualize K centroid images for each category.
             real_label = labeling(k, testing_label, test_label, num_test)
             visualizer(k, centroid, real_label)
```

```
# Plot the training energy per optimization iteration.
plt.plot(energy, label='Training Energy')
plt.legend(loc='lower right')
plt.show()

# Plot the training accuracy per optimization iteration.
plt.plot(train_accuracy, label='Training Accuracy')
plt.legend(loc='lower right')
plt.show()

# Plot the testing accuracy per optimization iteration.
plt.plot(test_accuracy, label='Testing Accuaracy')
plt.legend(loc='lower right')
plt.show()
```

13 Function: Energy

$\sum_{k=1}^{K} \|x_i - c_{k_i}\|^2$
where k_i denotes the category of x_i, and c_{k_i} denotes the centroid of category x_i

```
In [12]: def calculate_energy(train_data, num_train, centroid, centroid_label):
             energy = 0

             for i in range(num_train):
                 energy += distance(train_data[:,i], centroid[:,centroid_label[i]])

             return(energy)
```

14 Function: Accurate

$\frac{\sum_{k=1}^{K} m_k}{N}$
where N denotes the total number of data and m_k denotes the number of data with majority for category k.

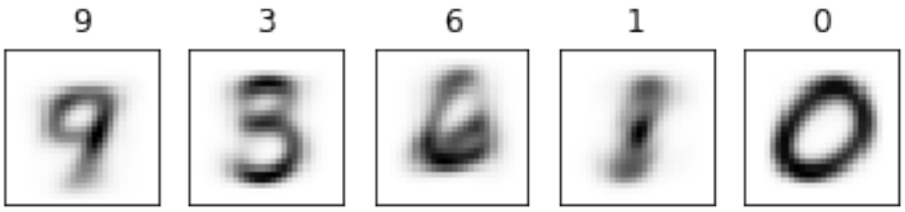
```
In [13]: def calculate_accuracy(k, cluster_label, data_label, num_data):
             label_check = np.zeros((k, 10), dtype=int)
             count = 0

             for i in range(num_data):
                 label_check[cluster_label[i], data_label[i]] += 1

             for i in range(num_data):
                 if(data_label[i] == np.argmax(label_check[cluster_label[i],:])):
                     count += 1

             return count/num_data
```

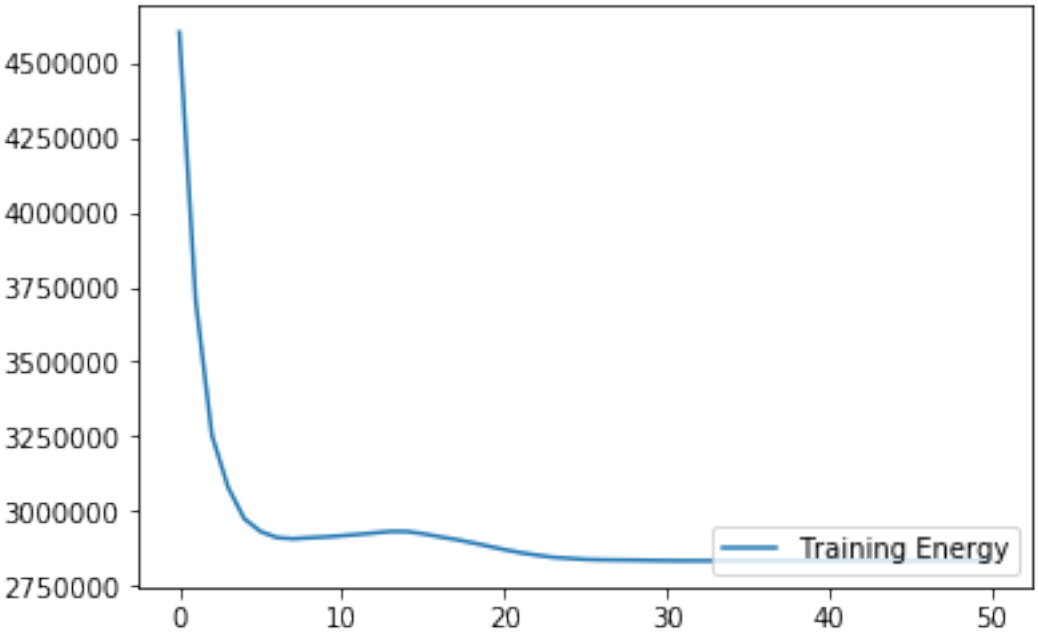
15 Preprocessing data / devide label and data

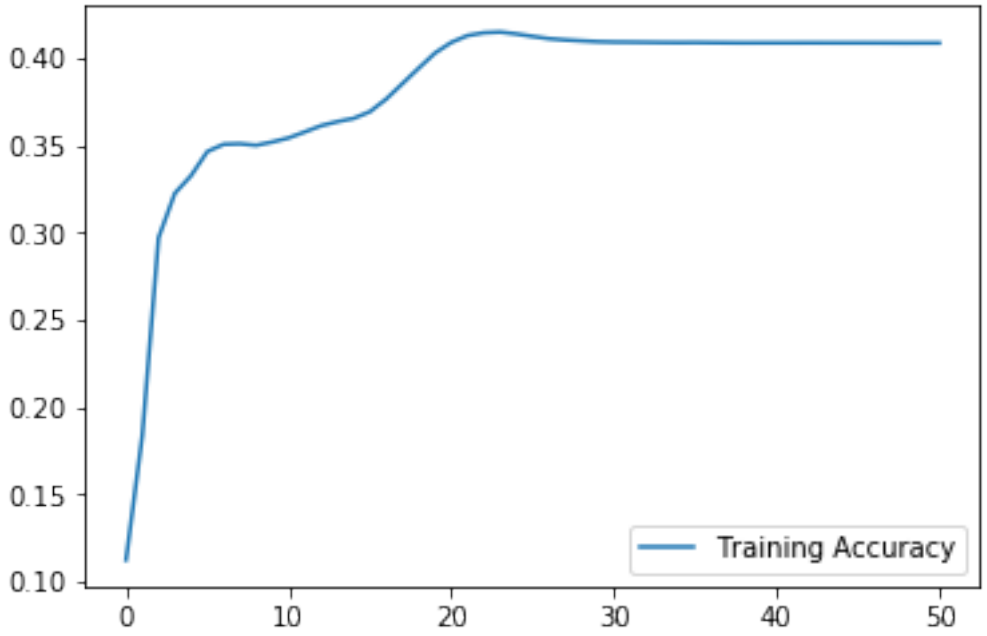
In [14]:
```
count = 0

for line in train_data:

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

    train_label[count]       = label
    train_image[:, count]    = im_vector
    count += 1

count = 0
for line in test_data:

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

    test_label[count]       = label
    test_image[:, count]    = im_vector
    count += 1
```

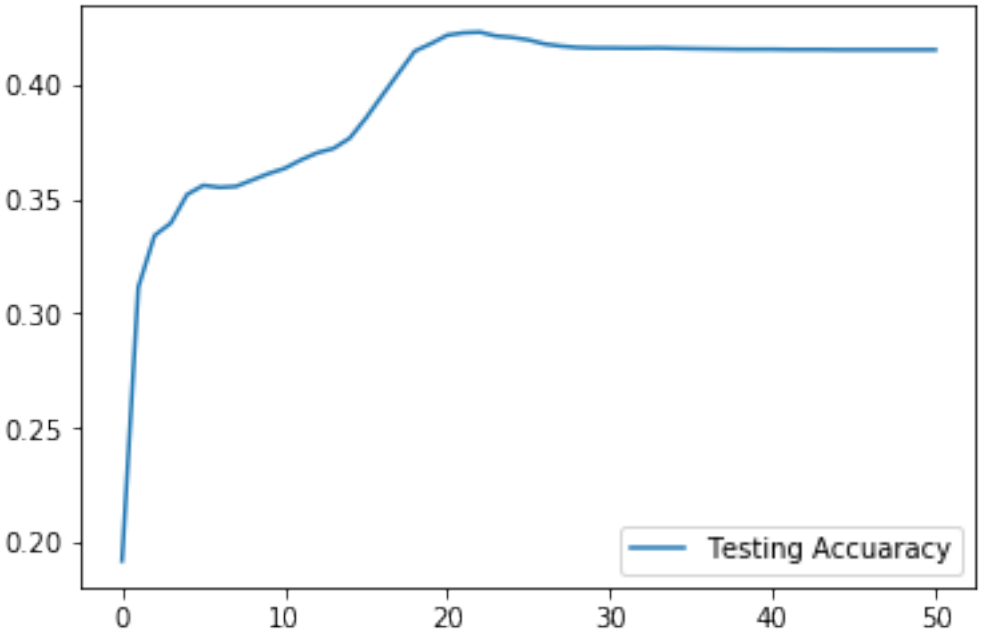
16 K = 5

In [15]:
```
k=5
k_means(k, train_image, train_label, num_train)
```



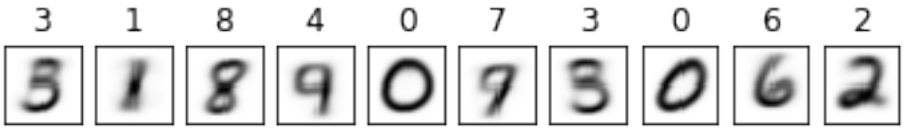

4500000
4250000
4000000
3750000
3500000
3250000
3000000
2750000
0
10
20
30
40
50
Training Energy

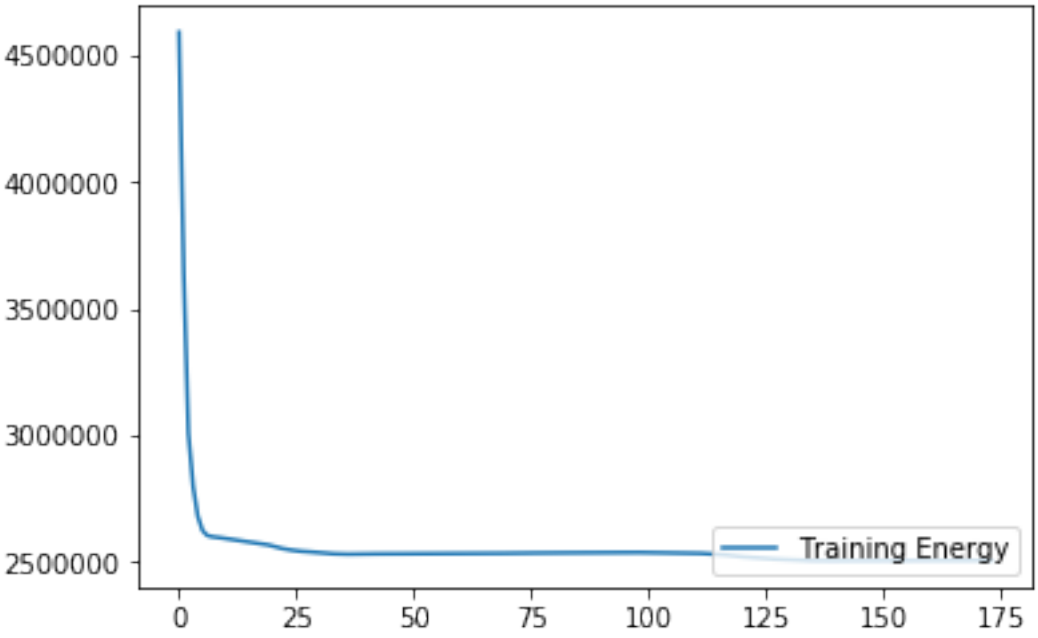

0.40
0.35
0.30
0.25
0.20
0.15
0.10
0
10
20
30
40
50
Training Accuracy

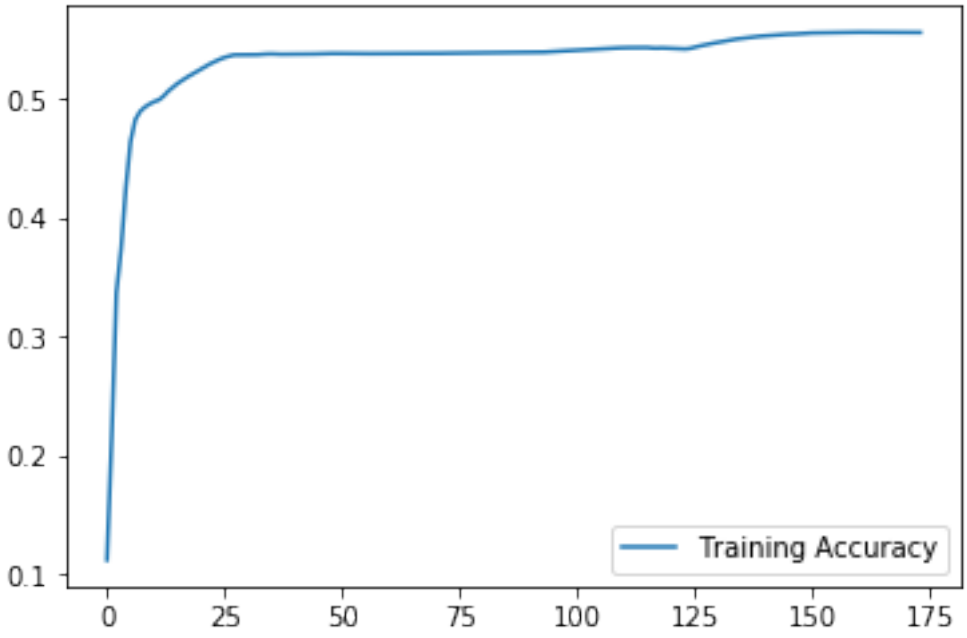


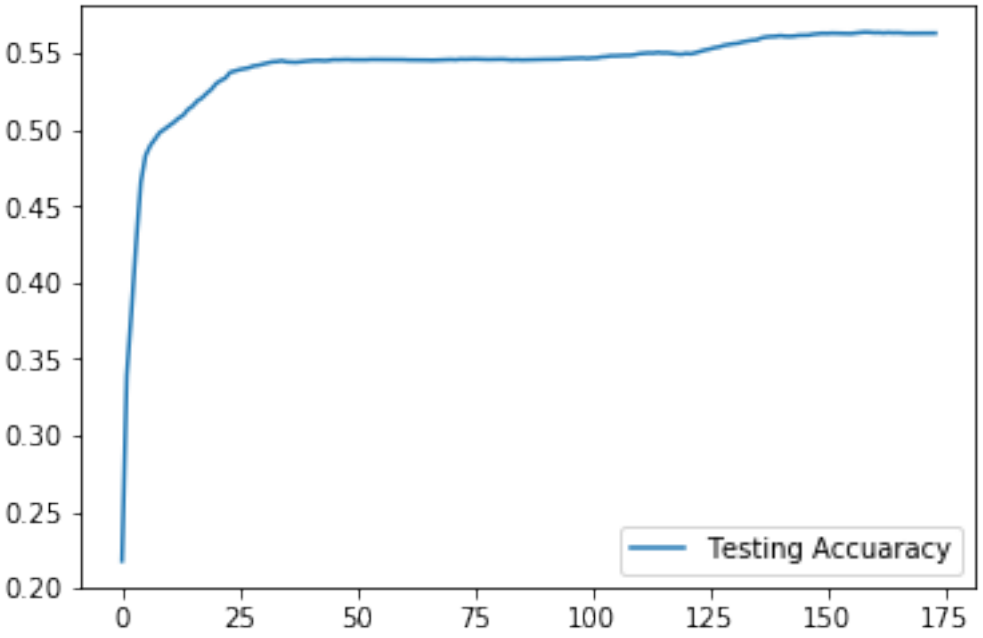
17 K = 10

In [16]:
```
k=10
k_means(k, train_image, train_label, num_train)
```



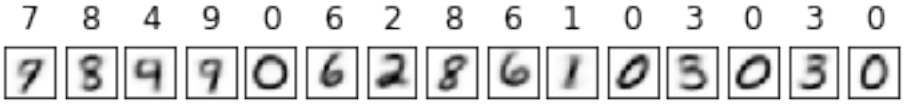

4500000
4000000
3500000
3000000
2500000
0
25
50
75
100
125
150
175
Training Energy

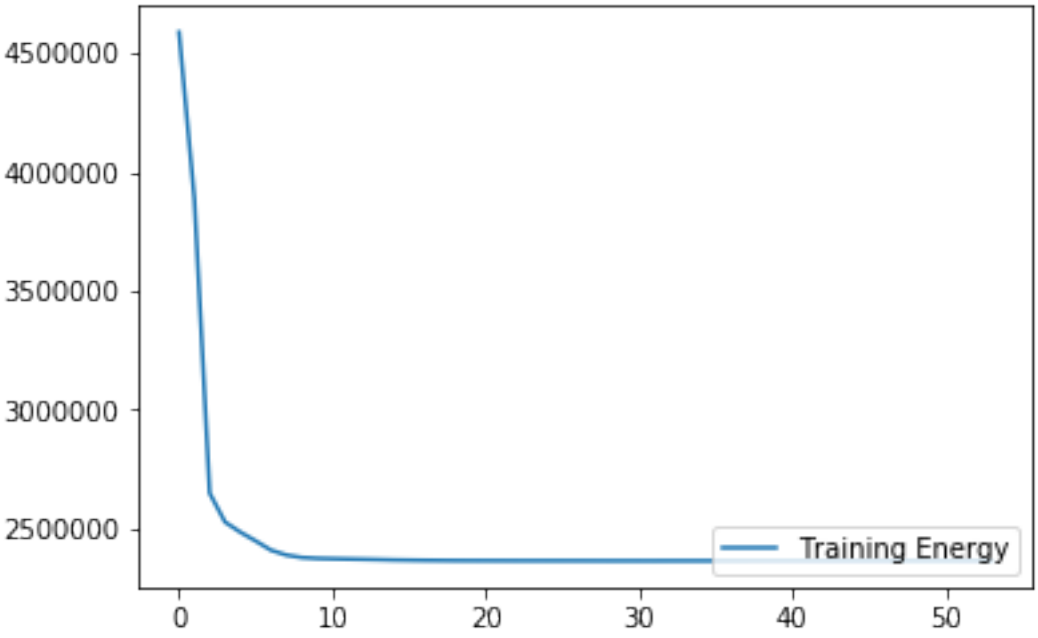

0.5
0.4
0.3
0.2
0.1
0
25
50
75
100
125
150
175
Training Accuracy

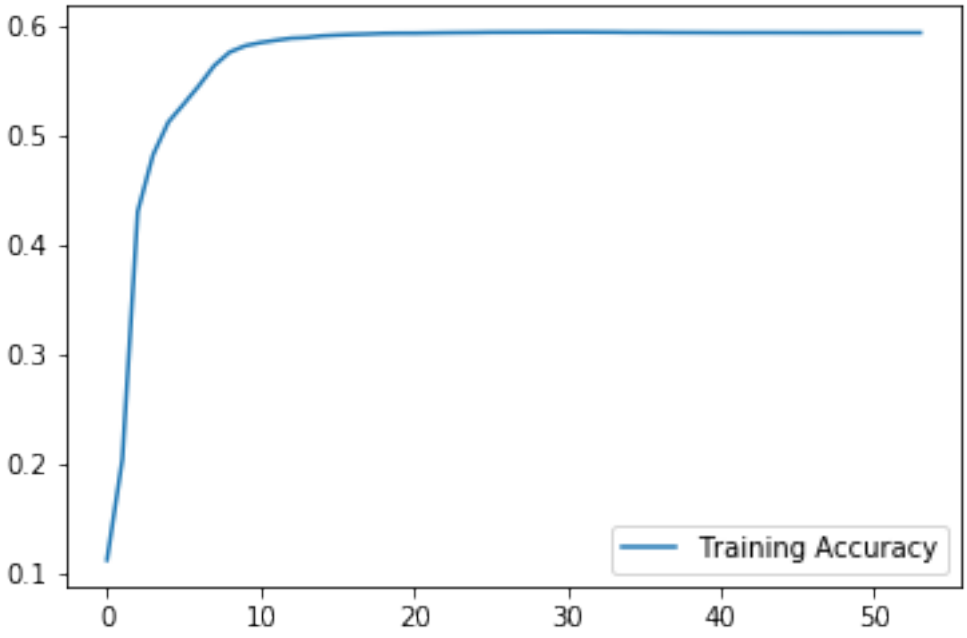


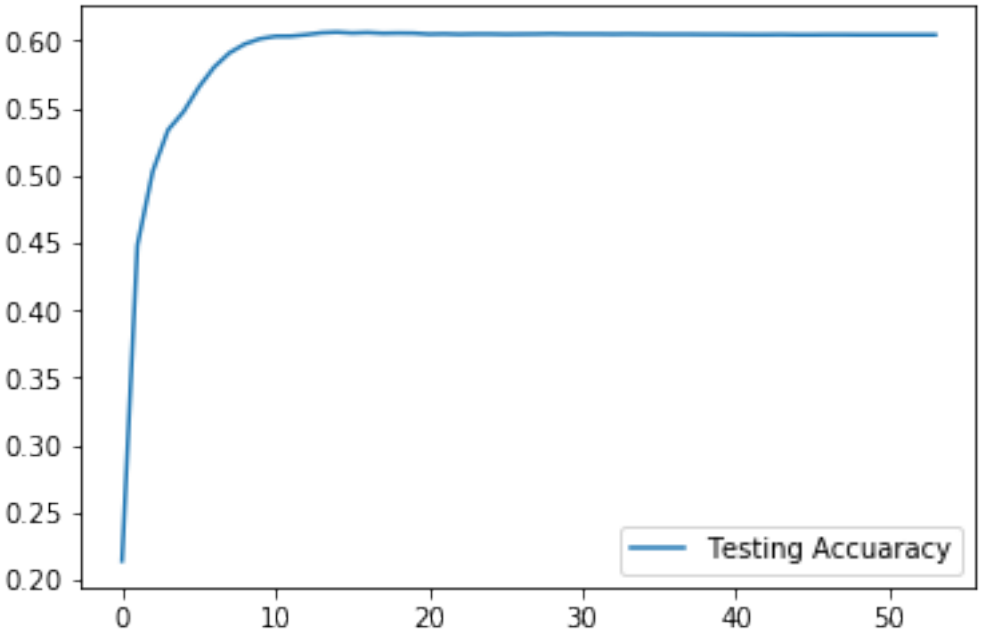
18 K = 15

In [17]:
```
k=15
k_means(k, train_image, train_label, num_train)
```



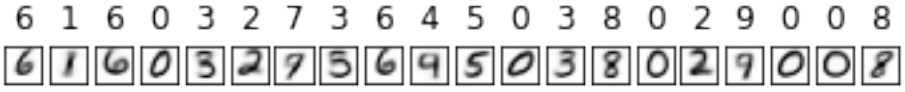

4500000
4000000
3500000
3000000
2500000
0
10
20
30
40
50
Training Energy

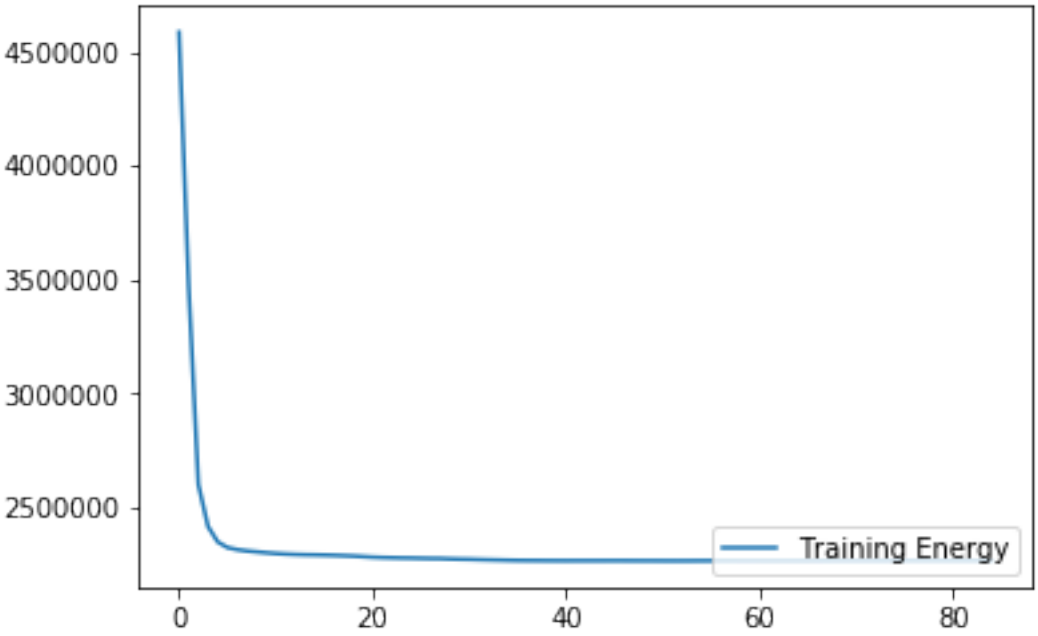

0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40
50
Training Accuracy

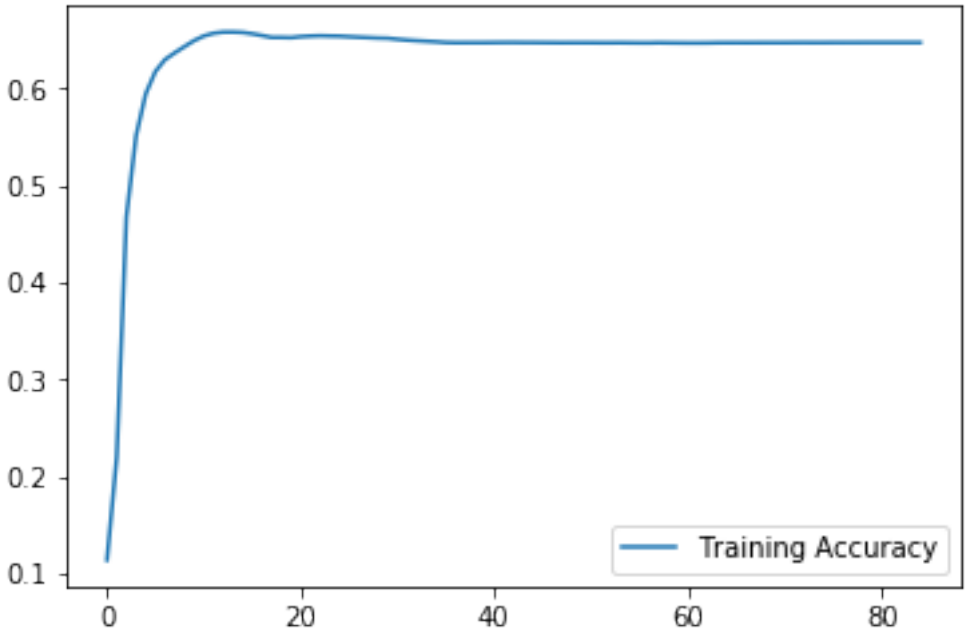


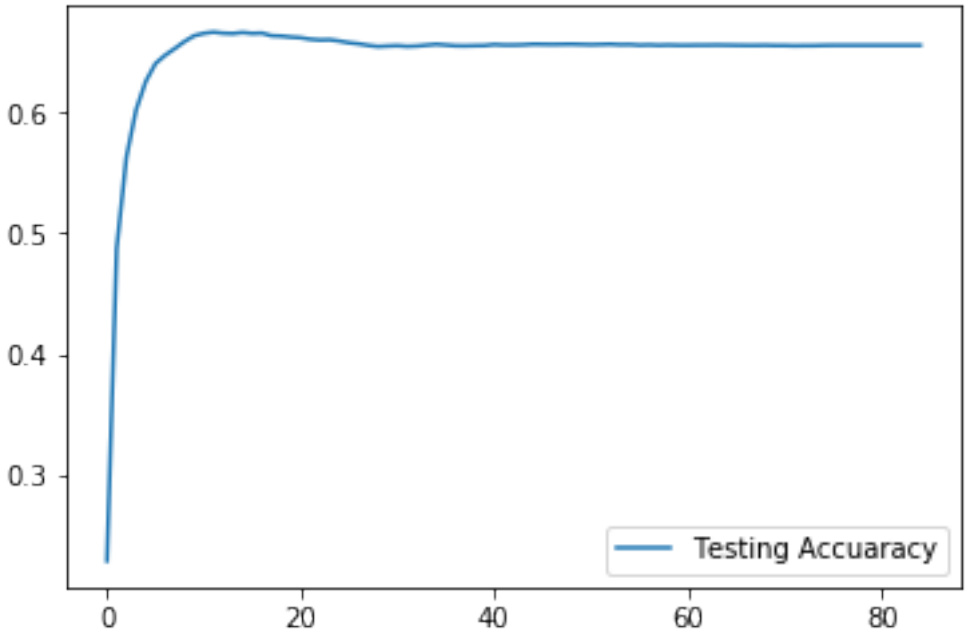
19 K = 20

In [18]:
```
k=20
k_means(k, train_image, train_label, num_train)
```




4500000
4000000
3500000
3000000
2500000
0
20
40
60
80
Training Energy


0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80
Training Accuracy



In [ ]: