Assignment04

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1 Load MNIST traning dataset.

```
In [1]: import matplotlib.pyplot as plt
        import numpy as np

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

        test_file_data = "mnist_test.csv"
        handle_test_file = open(test_file_data,"r")
        test_data = handle_test_file.readlines()
        handle_test_file.close()

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

        num_image        = len(data)
        test_num_image = len(test_data)

        E = []
        A = []
        tA = []
```

2 Nomarlization

```
In [2]: def normalize(data):

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

            return(data_normalized)
```

3 Make label, image array with train data

```
In [3]: list_image  = np.empty((size_row * size_col, num_image), dtype=float)
        list_label  = np.empty(num_image, dtype=int)
        count = 0

        for line in data:

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

            list_label[count]       = label
            list_image[:, count]    = im_vector

            count += 1
```

4 Make label, image array with test data

```
In [4]: test_list_image  = np.empty((size_row * size_col, test_num_image), dtype=float)
        test_list_label  = np.empty(test_num_image, dtype=int)
        test_count = 0

        for test_line in test_data:

            test_line_data   = test_line.split(',')
            test_label       = test_line_data[0]
            test_im_vector   = np.asfarray(test_line_data[1:])
            test_im_vector   = normalize(test_im_vector)

            test_list_label[test_count]       = test_label
            test_list_image[:, test_count]    = test_im_vector

            test_count += 1
```

5 Compute distance based on L2-norm (x, (0,0))

$$||x - y||_2 = \sqrt{x^2 + y^2}$$

```
In [5]: def distance(x,y):
            d = (x - y) ** 2
            s = np.sum(d)
            r = np.sqrt(s)

            return r
```

6 Initialize Label

initialize all images with random label

```
In [6]: def initialLabel(list_image, cluster_num):
            cluster_label = np.zeros(num_image, dtype=int)
            for i in range(num_image):
                initial_num = np.random.randint(0, cluster_num)
                cluster_label[i] = initial_num

            return cluster_label
```

7 Initialize Centroid

```
In [7]: def initialCentroid(list_image, cluster_num, cluster_label, im_average, im_count):

            for i in range(num_image):
                im_average[:,cluster_label[i]] += list_image[:,i]
                im_count[cluster_label[i]] += 1

            return im_average, im_count
```

8 Plot the Average Image

Plot initial and final image

```
In [8]: def plot_average(im_average, im_count, cluster_num):
            f1 = plt.figure(1)

            for i in range(cluster_num) :
                im_average[:,i] /= im_count[i]
                im_L2matrix = im_average[:,i].reshape((size_row,size_col))

                plt.subplot(cluster_num/5 ,5,i+1)
                plt.title("C" + str(i) )
                plt.imshow(im_L2matrix, cmap='Greys', interpolation = 'None')

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

            plt.show()

            return im_average
```

9 Clustering

```
In [9]: def clustering(list_image, num_image, cluster_label, cluster_num, im_average):
            cluster_element = []

            for i in range(cluster_num):
                cluster_element.append([])

            for i in range(num_image):
                dist = []
                for j in range(cluster_num):
                    x = list_image[:, i]
                    y = im_average[:, j]
                    dist.append(distance(x, y))
                cluster_label[i] = np.argmin(dist)
                cluster_element[cluster_label[i]].append(i)

            return cluster_element, cluster_label
```

10 Compute Centroid

$$C_A = \frac{1}{n_A}\Sigma x_i$$

```
In [10]: def computeCentroid(cluster_num, cluster_label):
             num = np.zeros((cluster_num))
             c = np.zeros((size_row*size_col, cluster_num))

             for i in range(num_image):
                 c[:,cluster_label[i]] += list_image[:,i]
                 num[cluster_label[i]] += 1

             for i in range(cluster_num):
                 c[:,i] /= num[i]

             return c
```

11 Compute Engergy

$$E = \frac{1}{N}\Sigma||x_i - c_k||^2$$

```
In [11]: def computeEnergy(cluster_label, cluster_num, im_average, num_image, list_image):
             total_sum = 0
             for i in range(num_image):
                 total_sum += sum((im_average[:,cluster_label[i]]- list_image[:,i]) ** 2)

             return total_sum
```

12 Compute Accuracy

$$A = \frac{1}{N}\Sigma count(x_i, c_k)$$

```
In [12]: def computeAccuracy(cluster_elements, cluster_label, cluster_num, list_label, num_imag
             total = 0
             a = np.zeros(cluster_num,dtype = int)

             for i in range(cluster_num):
                 in_label = np.zeros(10, dtype = int)
                 for j in range(len(cluster_elements[i])):
                     in_label[list_label[cluster_elements[i][j]]] += 1

                 a[i] = np.argmax(in_label)
                 total += in_label[a[i]]

             total /= num_image
             return total
```

13 Initialize Cluster

```
In [13]: def initialCluster(cluster_num):
             im_average  = np.zeros((size_row * size_col, cluster_num), dtype=float)
             im_count = np.zeros(cluster_num, dtype=int)

             cluster_label = initialLabel(list_image, cluster_num)

             im_average, im_count = initialCentroid(list_image, cluster_num, cluster_label,im_a
             im_average = plot_average(im_average, im_count, cluster_num)

             E.clear()
             A.clear()
             tA.clear()

             return im_average, im_count, cluster_label
```

14 Clustering until no change

no change means energy is maintained

```
In [14]: def iteration(cluster_num, im_average, im_count, cluster_label):
             iter_num = 0
             while True:
                 cluster_element, cluster_label = clustering(list_image, num_image, cluster_lab
                 t_cluster_element, t_cluster_label = clustering(test_list_image, test_num_imag

                 im_average = computeCentroid(cluster_num, cluster_label)
```

```
            E.append(computeEnergy(cluster_label, cluster_num, im_average,num_image, list_
            A.append(computeAccuracy(cluster_element, cluster_label, cluster_num, list_lab
            tA.append(computeAccuracy(t_cluster_element, t_cluster_label, cluster_num, tes


            if iter_num >= 1 :
                if E[iter_num -1] == E[iter_num]:
                    break
            iter_num += 1

        plot_average(im_average, im_count, cluster_num)
        return iter_num
```

15 Energy graph per each iteration

```
In [15]: def drawEnergy(iter_num):
             plt.figure(3)
             x_range = np.arange(iter_num+1)
             plt.plot(x_range, E, "g")
             plt.title("Energy")
             plt.grid(True)
             plt.show()
```

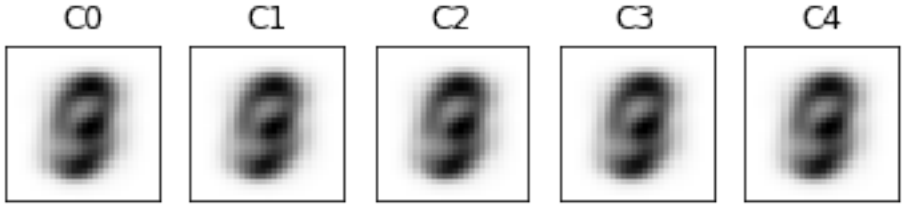
16 Accuracy graph per each iteration

```
In [16]: def drawAccuracy(iter_num, A,name):
             plt.figure(4)
             x_range = np.arange(iter_num+1)
             plt.plot(x_range, A, "r")
             plt.title("accuracy - " + str(name))
             plt.grid(True)
             plt.show()
```

17 K = 5

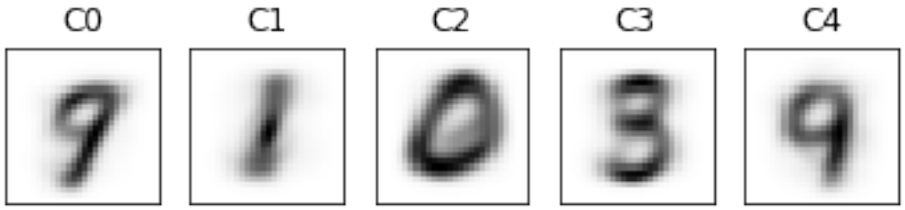
17.1 Initial average image

```
In [17]: im_average, im_count, cluster_label = initialCluster(5)
```



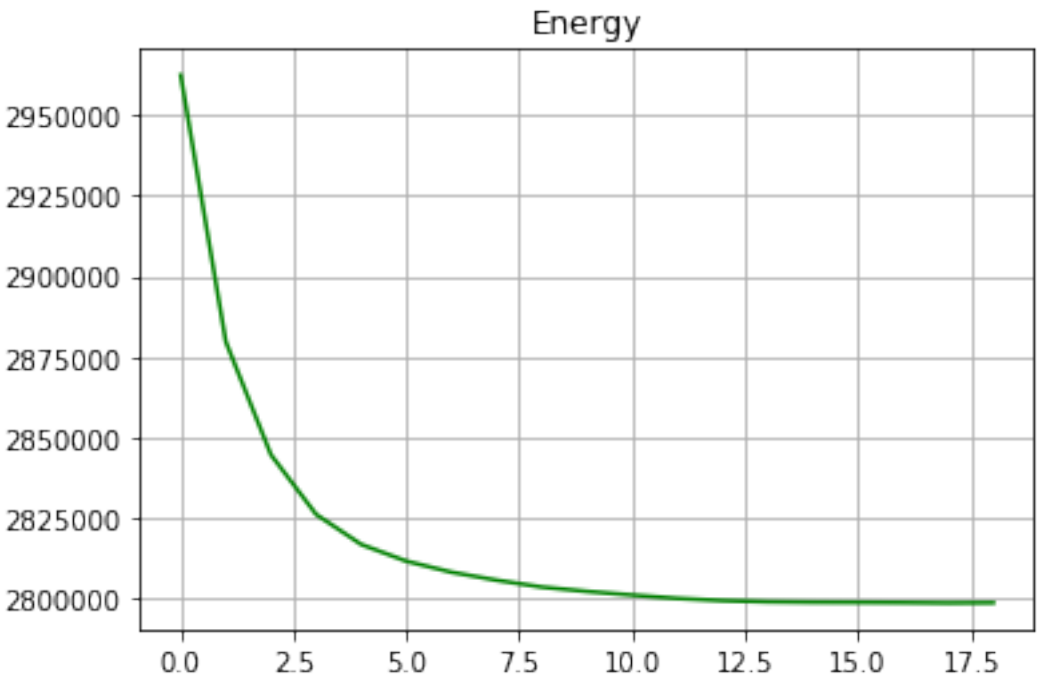
17.2 Final average image

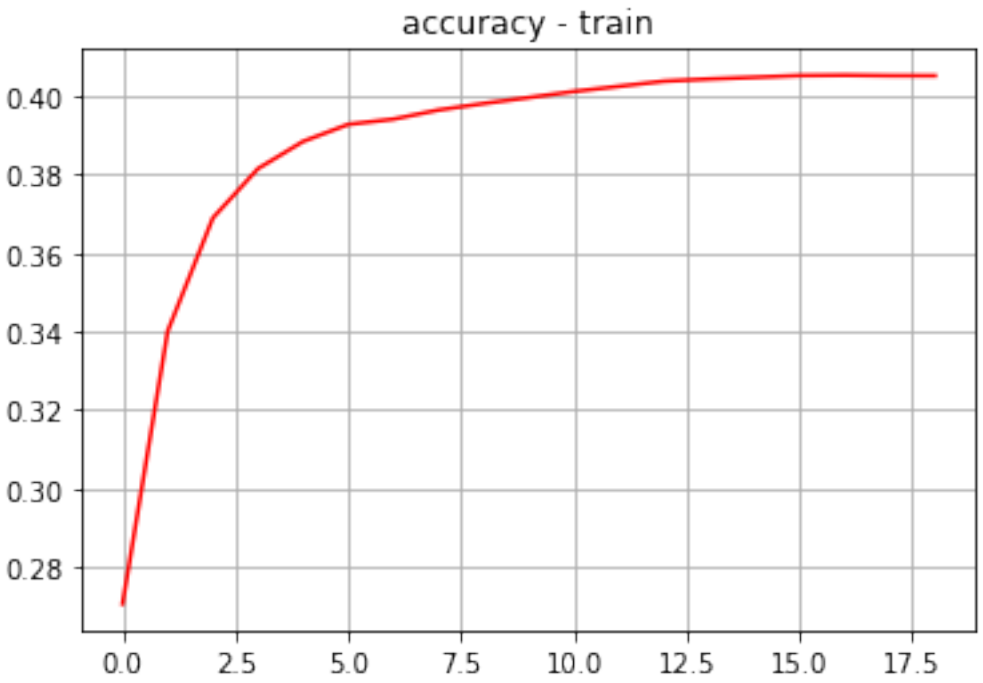
```
In [18]: iter_num = iteration(5,im_average, im_count, cluster_label)
```

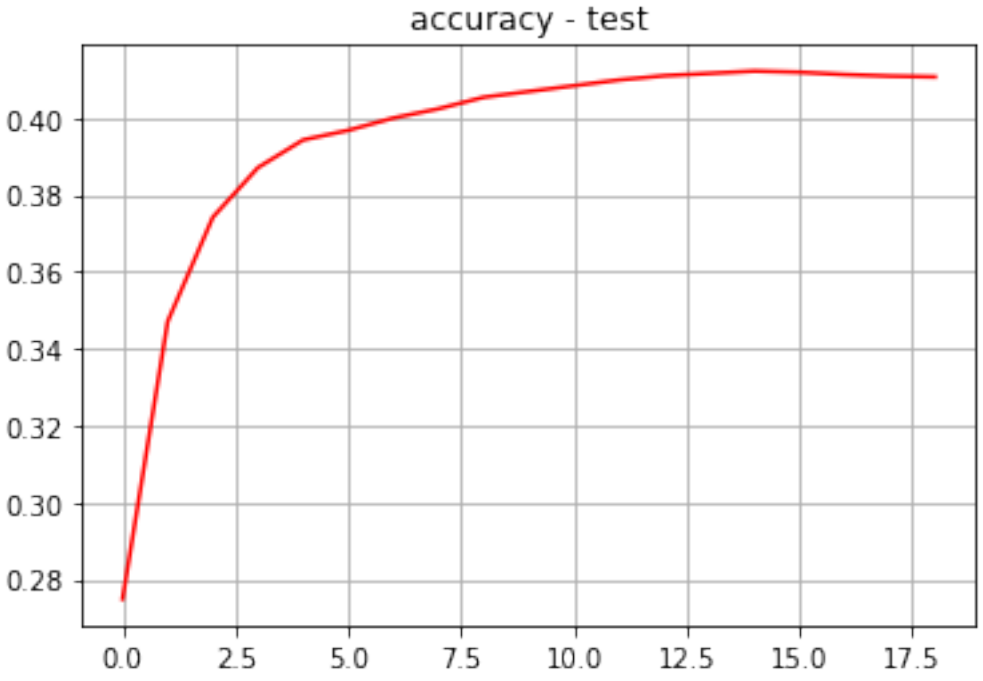


17.3 Energy, Accuracy graphs

```
In [19]: drawEnergy(iter_num)
         drawAccuracy(iter_num,A,"train")
         drawAccuracy(iter_num,tA,"test")
```



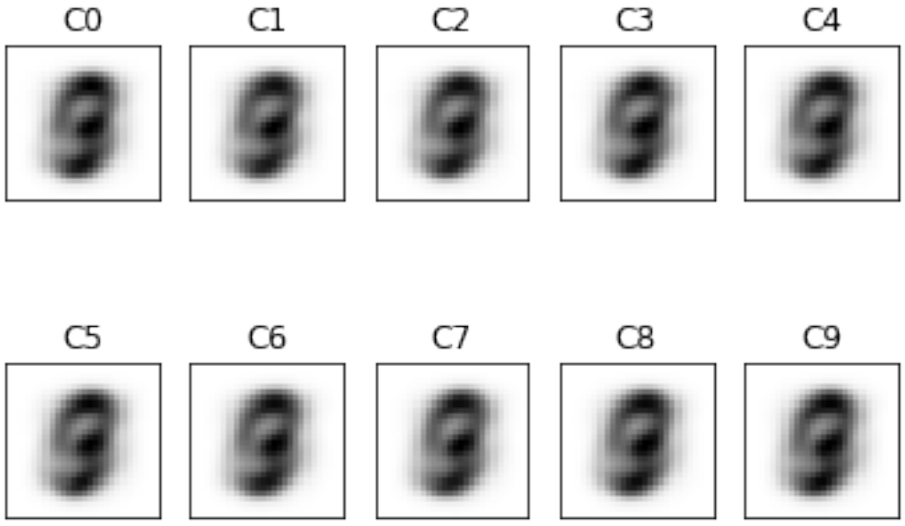

accuracy - train
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5


accuracy - test
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

18 K = 10

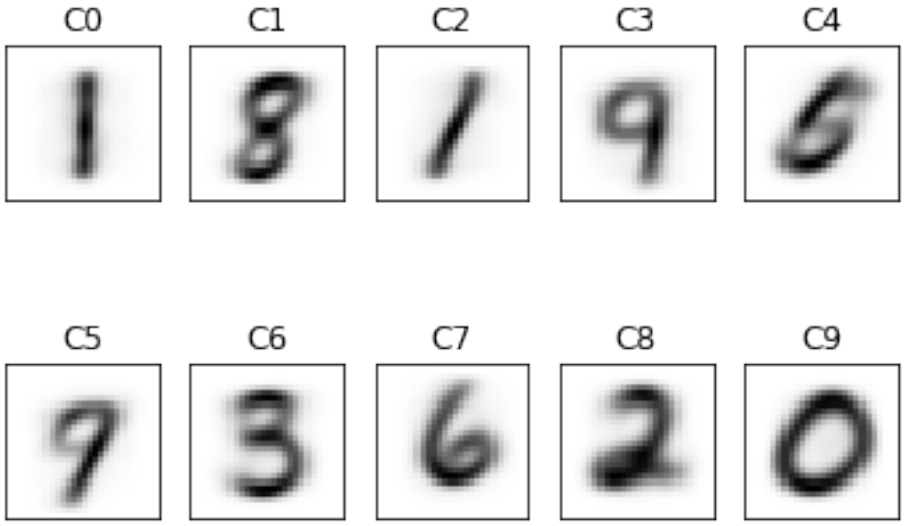
18.1 Initial average image

```
In [20]: im_average, im_count, cluster_label = initialCluster(10)
```



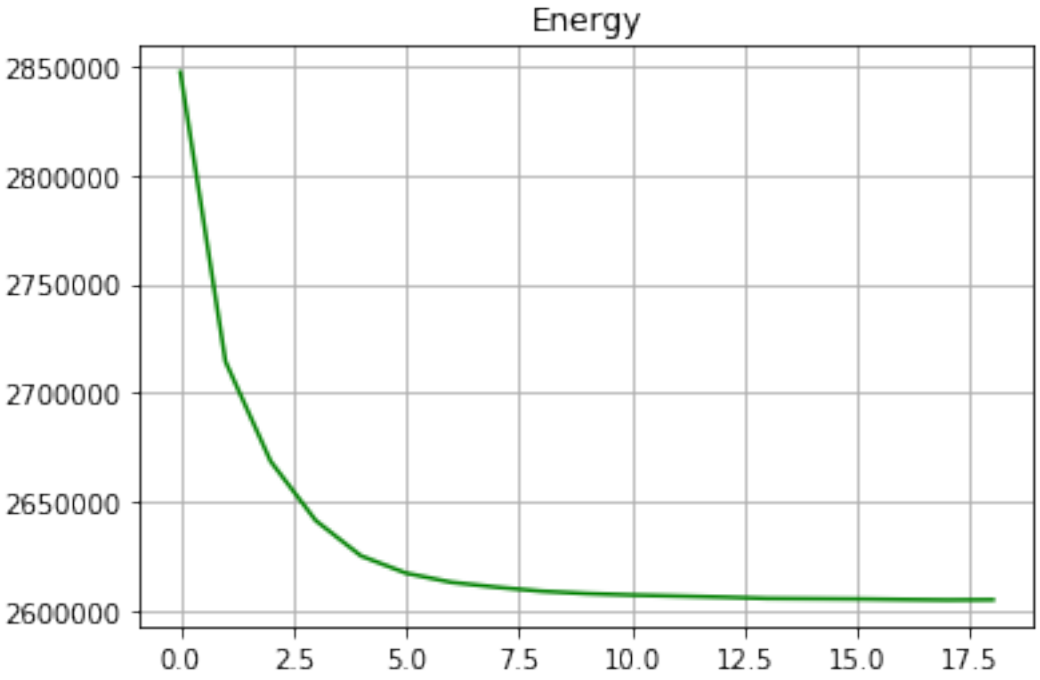
18.2 Final average image

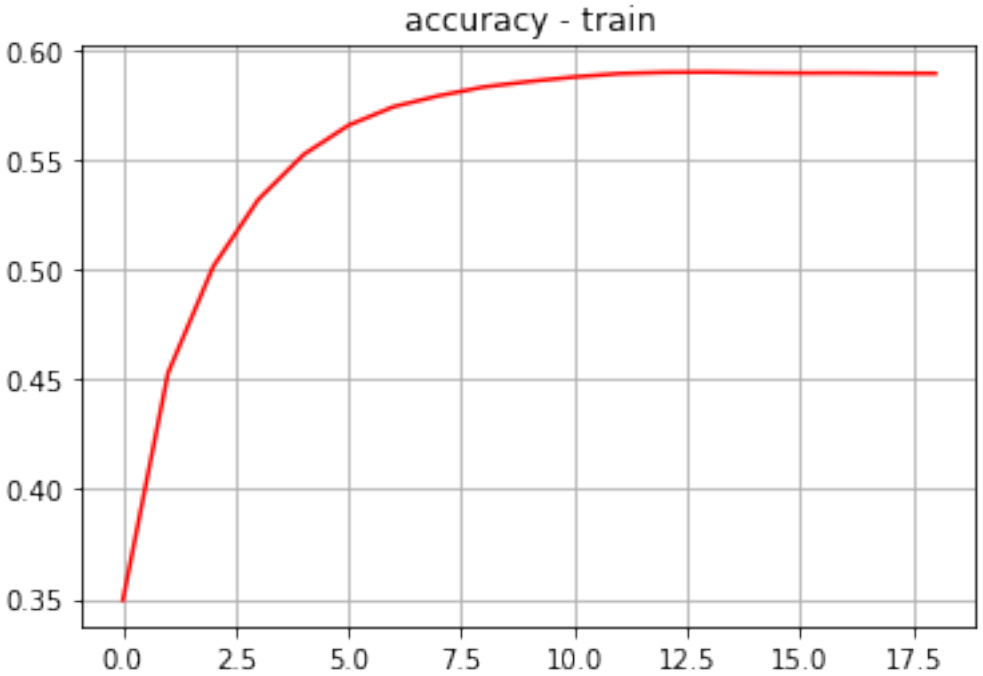
```
In [21]: iter_num = iteration(10,im_average, im_count, cluster_label)
```

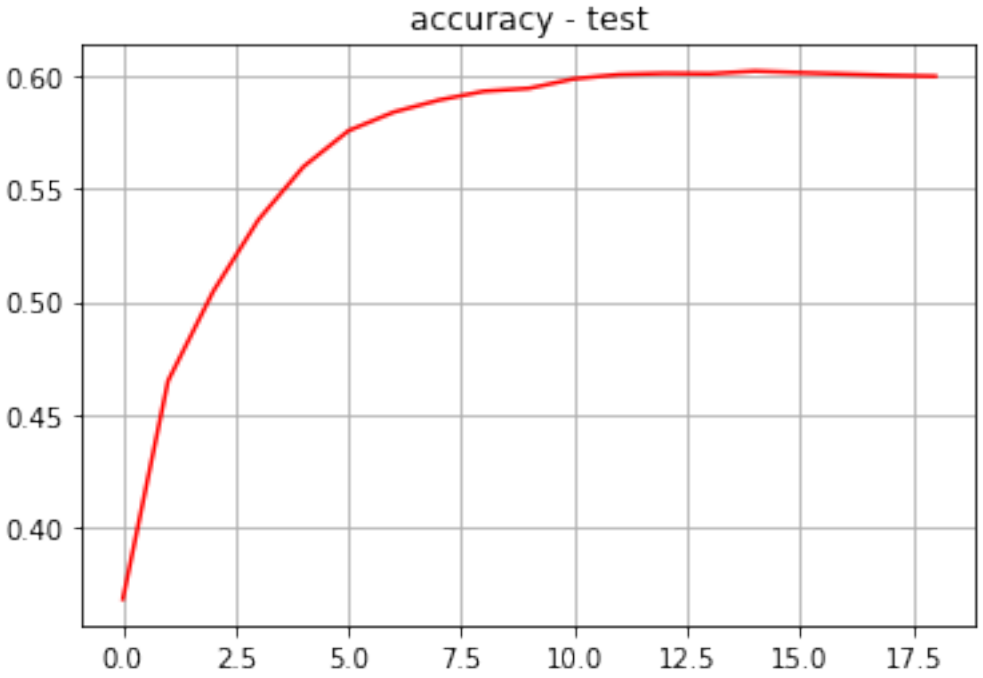


18.3 Energy, Accuracy graphs

In [22]:
```
drawEnergy(iter_num)
drawAccuracy(iter_num,A,"train")
drawAccuracy(iter_num,tA,"test")
```



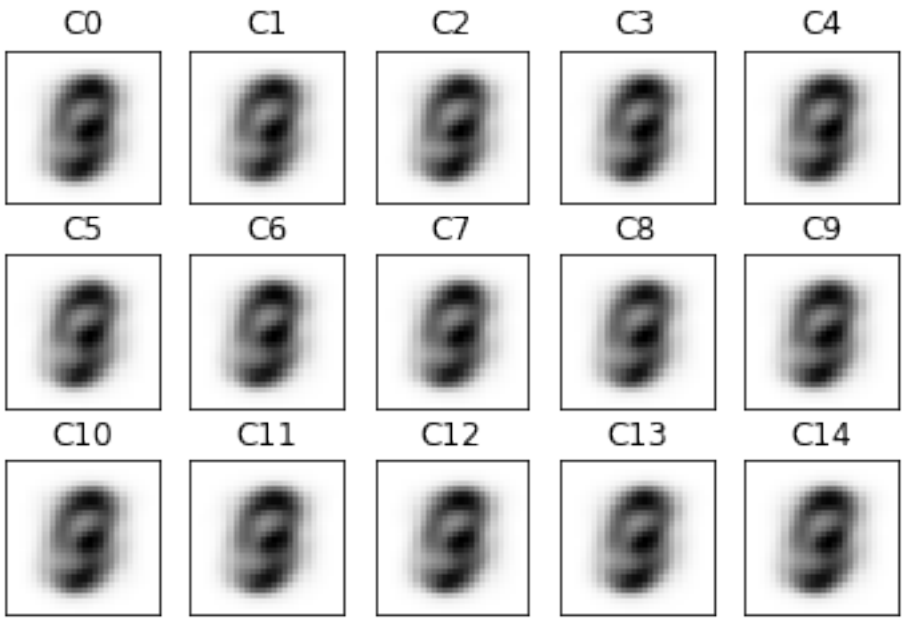




19 K = 15

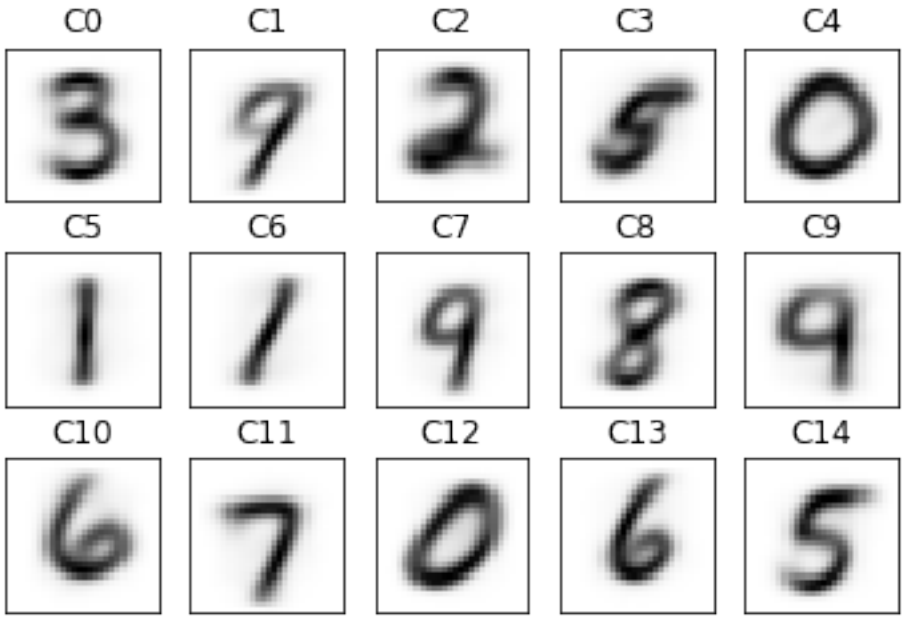
19.1 Initial average image

In [23]: `im_average, im_count, cluster_label = initialCluster(15)`



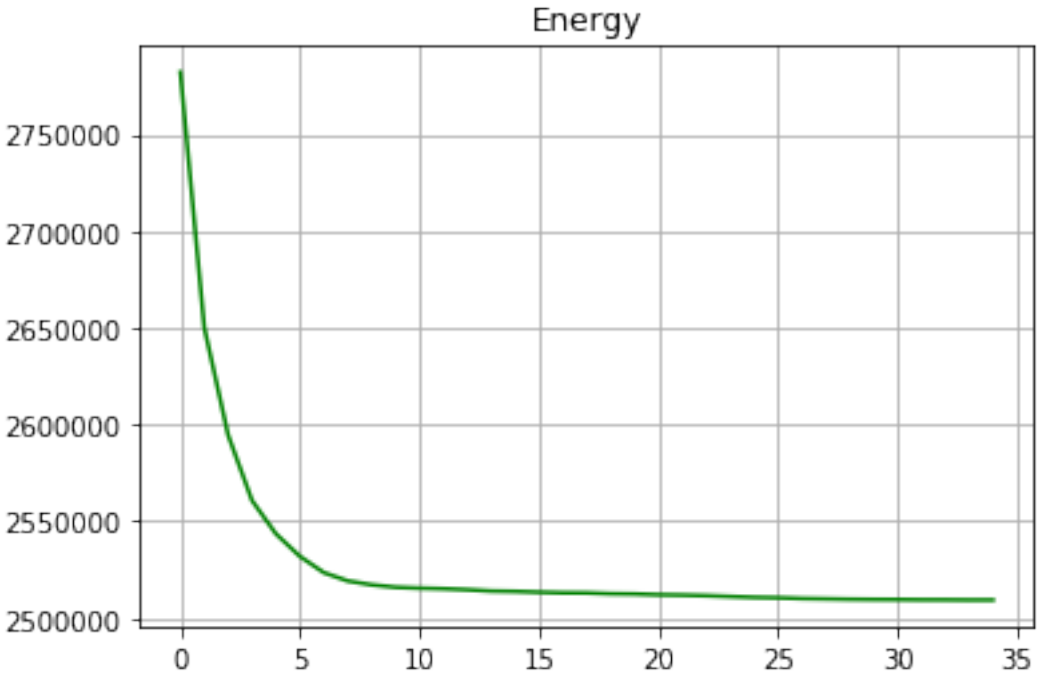
19.2 Final average image

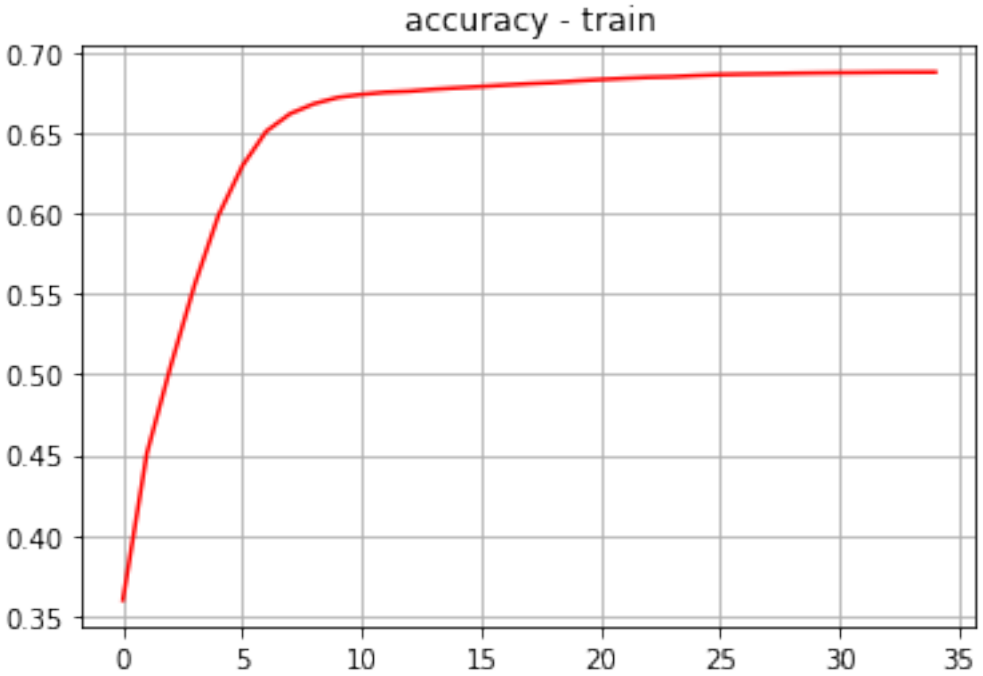
```
In [24]: iter_num = iteration(15,im_average, im_count, cluster_label)
```

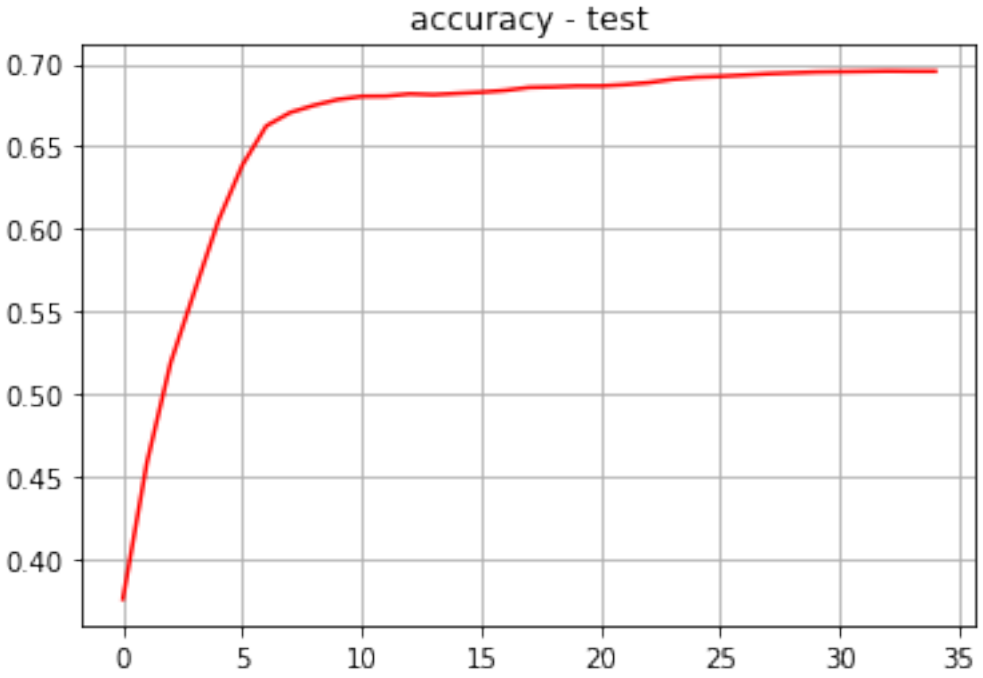


19.3 Energy, Accuracy graphs

In [25]:
```
drawEnergy(iter_num)
drawAccuracy(iter_num,A,"train")
drawAccuracy(iter_num,tA,"test")
```



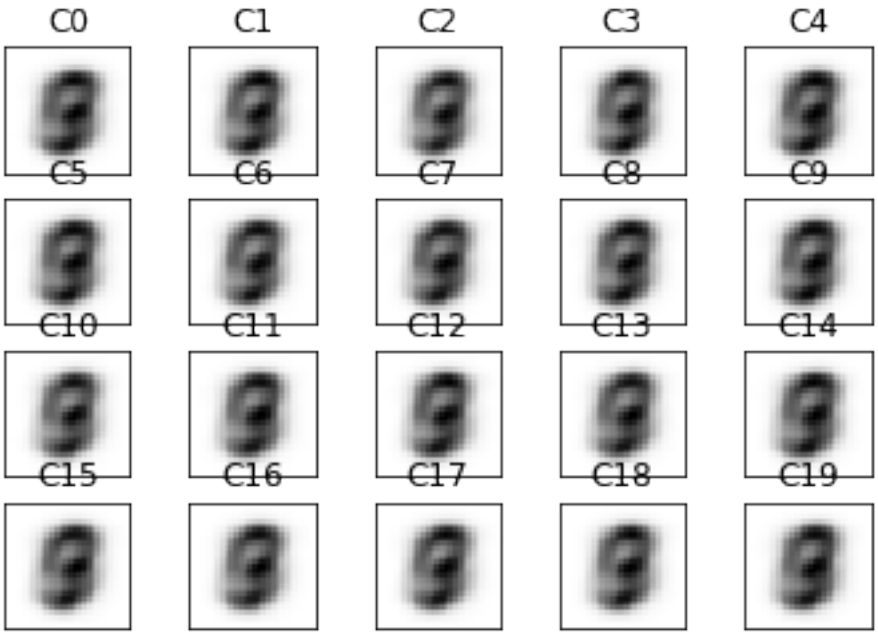




20 K = 20

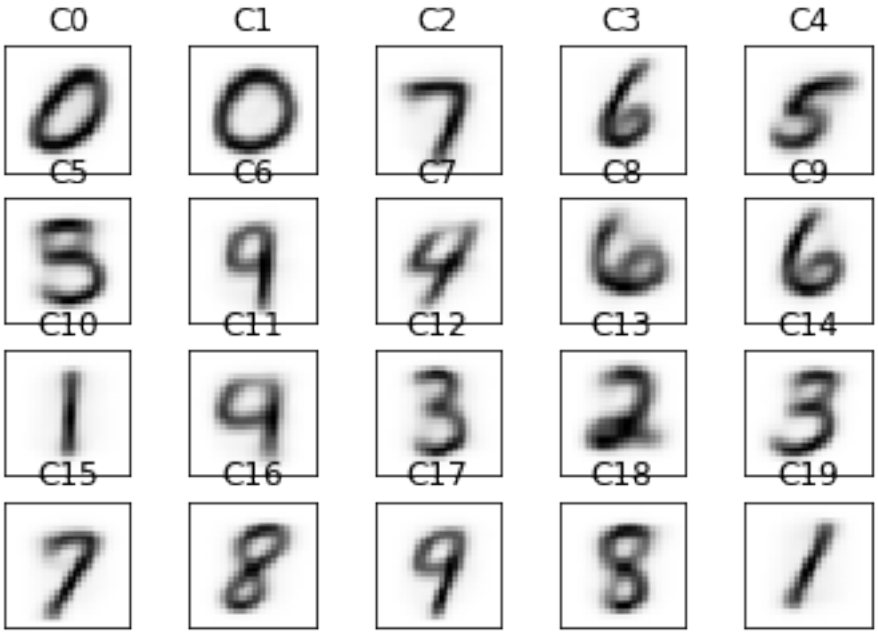
20.1 Initial average image

In [26]: `im_average, im_count, cluster_label = initialCluster(20)`



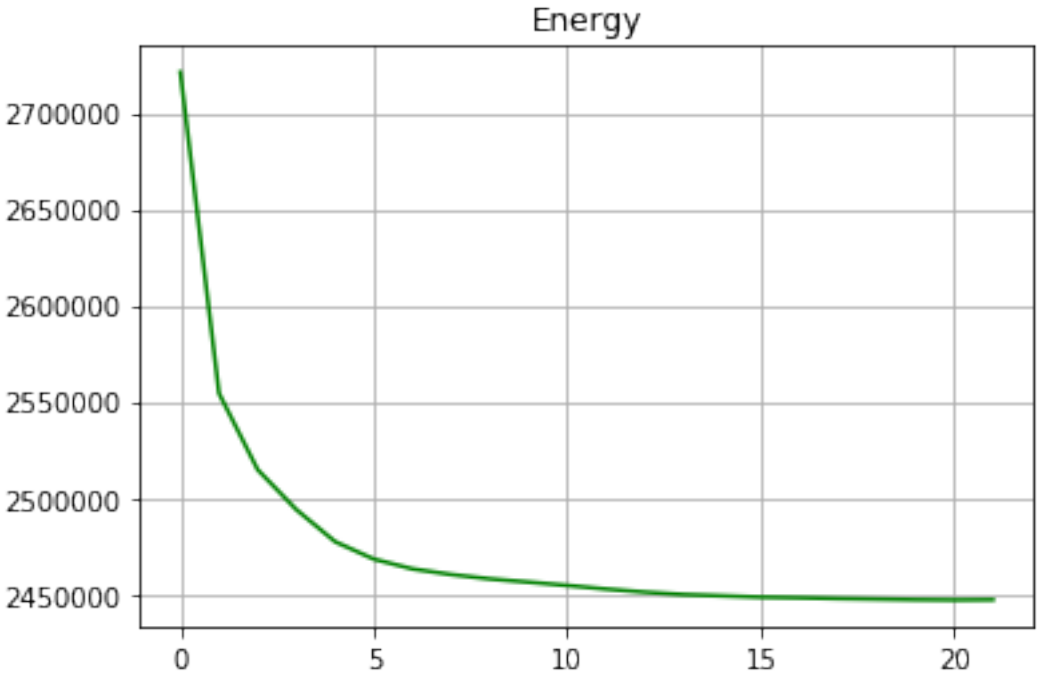
20.2 Final average image

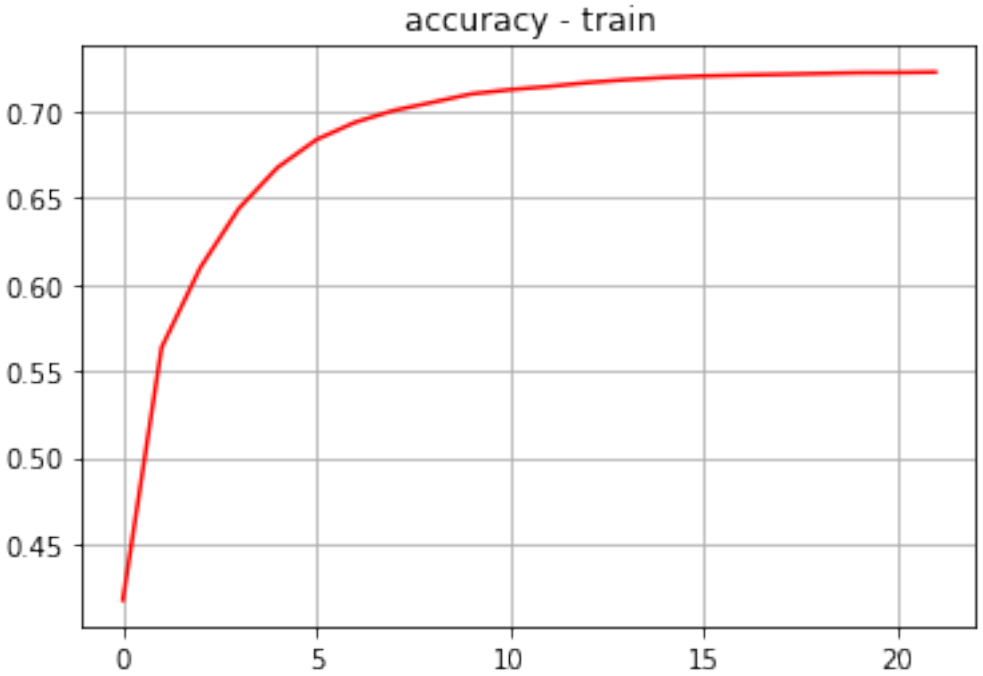
```
In [27]: iter_num = iteration(20,im_average, im_count, cluster_label)
```

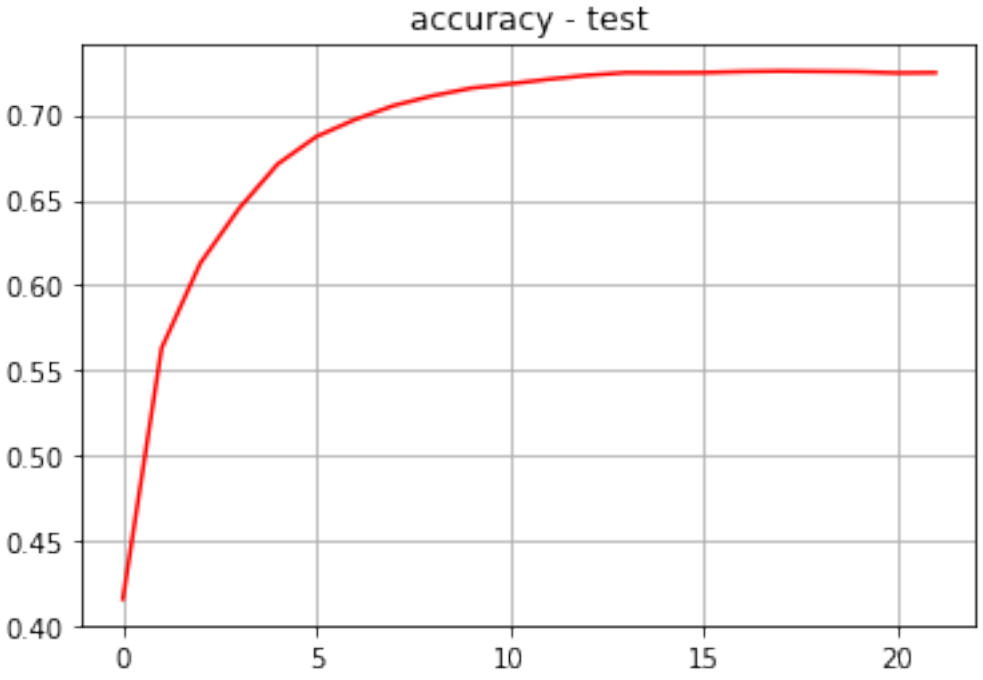


20.3 Energy, Accuracy graphs

```
In [28]: drawEnergy(iter_num)
         drawAccuracy(iter_num,A,"train")
         drawAccuracy(iter_num,tA,"test")
```






accuracy - test
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0
5
10
15
20