assignment04

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This script demonstrates the k-means algorithm for MNIST images

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github : https://github.com/ppooiiuuyh/datamining_assignments/tree/master/assignment04

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import modules

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

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prepare global variables

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```
In [2]: # ----------------------------------------------------------
        # prepare global variables : global parameters
        # ----------------------------------------------------------
        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_clusters = 10

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


        # ----------------------------------------------------------
        # prepare global variables : make a matrix each column of which represents an images in
        # ----------------------------------------------------------
```

```
    list_image  = np.empty((size_row * size_col, num_image), dtype=float)
    list_true_label  = np.empty(num_image, dtype=int)
    list_label  = np.empty(num_image, dtype=int)

    # -----------------------------------------------------------
    # evaluation histories
    # -----------------------------------------------------------
    acc_hist = []
    eng_hist = []
```

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functions

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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)
```

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(r)
```

In [5]:
```
    # -----------------------------------------------------------
    # init label for k-means clusturing
    # -----------------------------------------------------------
    def initialiseLabel(num_clusters):
        list_label_ = np.random.choice(num_clusters,num_image,replace=True)
        return list_label_
```

In [6]:
```
    # -----------------------------------------------------------
    # computeCentroid
    # -----------------------------------------------------------
    def computeCentroid():
        list_centroid = np.empty((size_row * size_col, num_clusters), dtype=float)
        list_clusters = [[] for i in range(num_clusters)]
        for i in range(num_image):
            list_clusters[int(list_label[i])].append(list_image[:,i])
```

```
            for i in range(num_clusters):
                list_centroid[:,i] = np.mean(list_clusters[i],axis=0)
            return list_centroid
```

In [7]:
```
        # ------------------------------------------------------------
        # plot average images
        # ------------------------------------------------------------
        def plot_avg_images():
            f2 = plt.figure(2)

            im_average = np.zeros((size_row * size_col, num_clusters), dtype=float)
            im_count = np.zeros(num_clusters, dtype=int)

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

            for i in range(num_clusters):
                im_average[:, i] /= im_count[i]

                plt.subplot(2, 5, i + 1)
                plt.title(i)
                plt.imshow(im_average[:, i].reshape((size_row, size_col)), cmap='Greys', interpo

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

In [8]:
```
        # ------------------------------------------------------------
        # plot centroid images
        # ------------------------------------------------------------
        def plot_centroid_images(images):
            f3 = plt.figure(3)

            for i in range(num_clusters):
                plt.subplot(2, num_clusters/2, i + 1)
                plt.title(i)
                plt.imshow(images[:, i].reshape((size_row, size_col)), cmap='Greys', interpolati

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

In [9]:
```
        # ------------------------------------------------------------------------
        # assign label
```

```
        # ------------------------------------------------------------------------
        def assignLabel():
            list_label_temp = np.empty(num_image,dtype= float)
            for i in range(num_image):
                list_dist = np.empty(num_clusters, dtype = float)
                for ii in range(num_clusters):
                    list_dist[ii] = distance(centroids[:,ii],list_image[:,i])
                list_label_temp[i] = np.argmin(list_dist)
            return list_label_temp
```

In [10]:
```
        # ------------------------------------------------------------------------
        # comput accuracy
        # ------------------------------------------------------------------------
        def computeAccuracy():
            cluster_temps = np.zeros((num_clusters,num_clusters))
            for i in range(num_image):
                cluster_temps[int(list_label[i]),int(list_true_label[i])] += 1
            acc_temps = np.max(cluster_temps,axis=-1) / np.sum(cluster_temps,axis=-1)
            return np.mean(acc_temps)
```

In [11]:
```
        # ------------------------------------------------------
        # comput energy
        # ------------------------------------------------------
        def computEnergy():
            cluster_temps = np.zeros(num_clusters)
            for i in range(num_image):
                cluster_temps[int(list_label[i])] += distance(centroids[:,int(list_label[i])],l
            eng_temps = np.mean(cluster_temps)
            return eng_temps
```

In [12]:
```
        # ------------------------------------------
        # plot history
        # ------------------------------------------
        def plot_centroid_history(history):
            f4 = plt.figure(4)
            plt.plot(history)
            plt.show()
```

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preprocessing

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In [13]:
```
        # ------------------------------------------------------
        # preprocessing : parse dataset
        # ------------------------------------------------------
        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_true_label[count]       = label
        list_image[:, count]    = im_vector
        count += 1
```

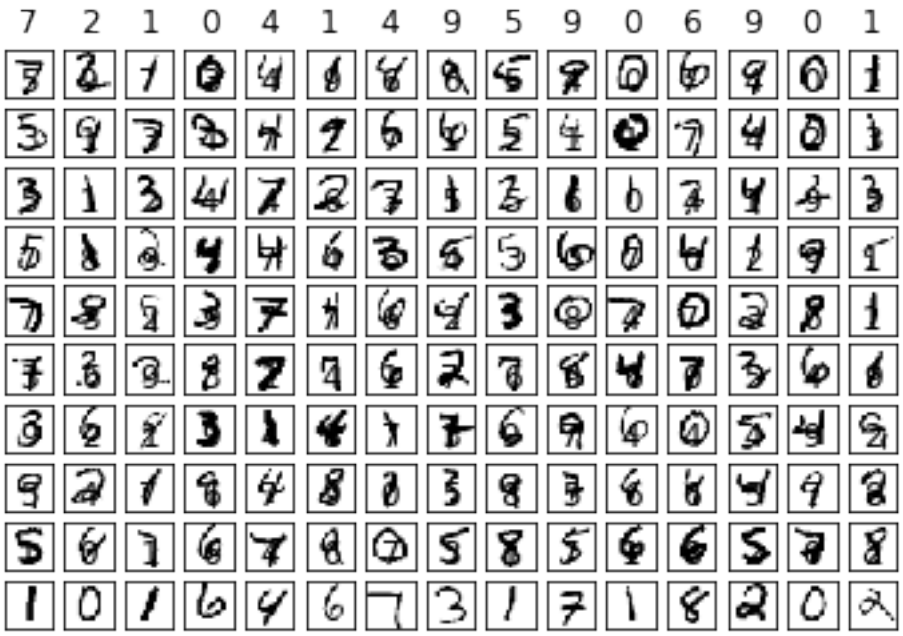
In [14]:
```
# ------------------------------------------------------------
# preprocessing : plot first 150 images out of 10,000 with their labels
# ------------------------------------------------------------
f1 = plt.figure(1)

for i in range(150):

    label       = list_true_label[i]
    im_vector   = list_image[:, i]
    im_matrix   = im_vector.reshape((size_row, size_col))

    plt.subplot(10, 15, i+1)
    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)
#plt.show()
```



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main algorithm
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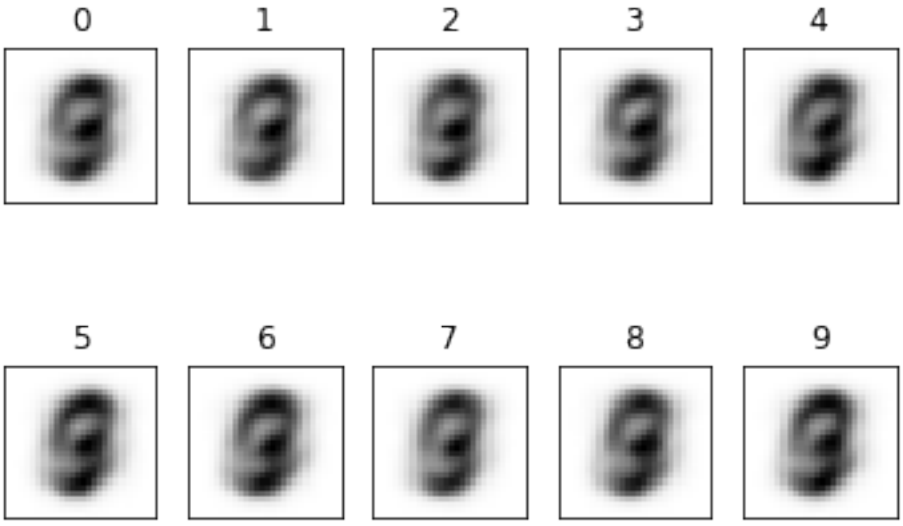
In [15]:
```
# init label
list_label = initialiseLabel(num_clusters)
# plot the average image of all the images for each digit
#plot_avg_images()
# computeCentroid
centroids = computeCentroid()
#plot initial centroid images(centroids)
plot_centroid_images(centroids)
```

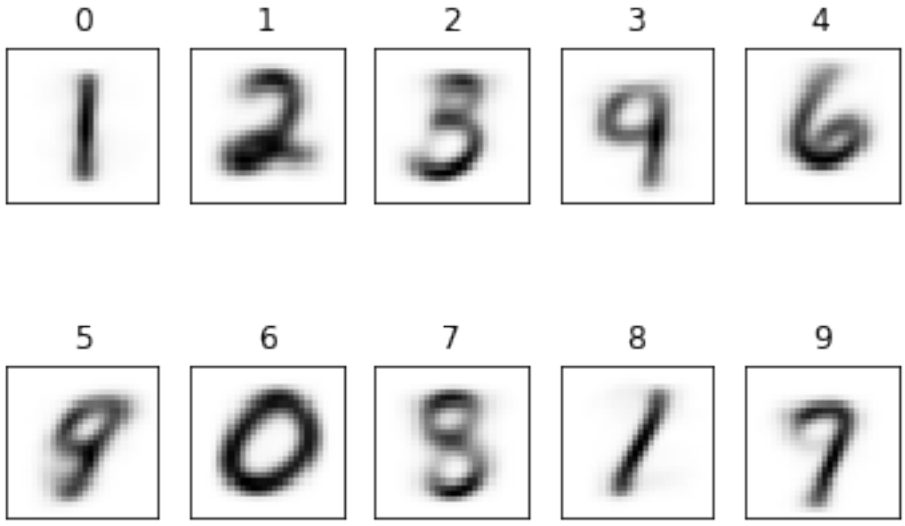


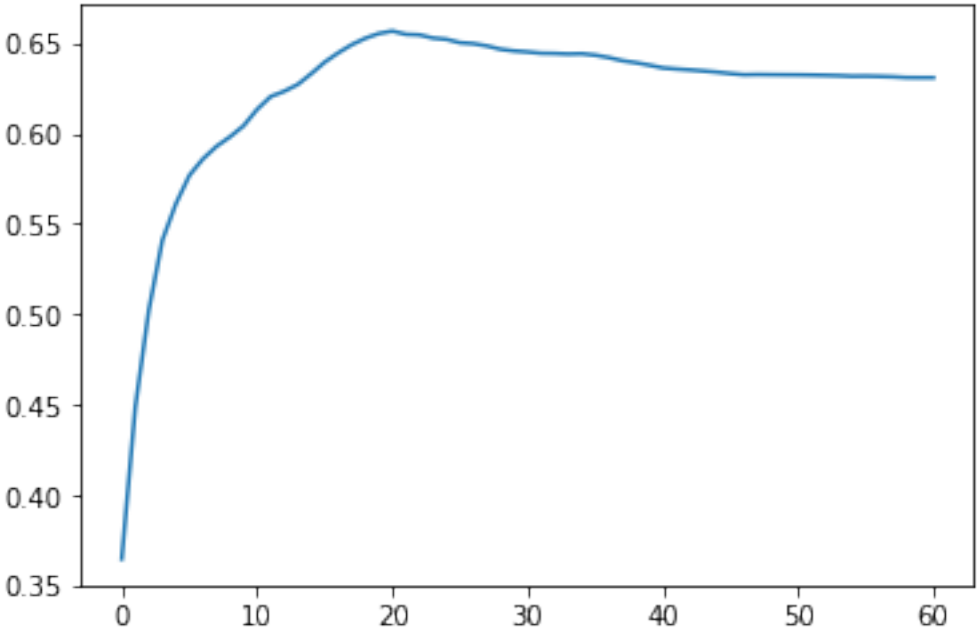
In [16]:
```
#clustering loop
while(not(len(acc_hist) > 2 and acc_hist[-1] == acc_hist[-2] and eng_hist[-1] == eng_hi
    # assign
    list_label = assignLabel()
    # assignLabel
    centroids = computeCentroid()
    # plot_centroid_images
    # plot_centroid_images(centroids)
    # compute histories
    acc_hist.append(computeAccuracy())
    eng_hist.append(computEnergy())
```

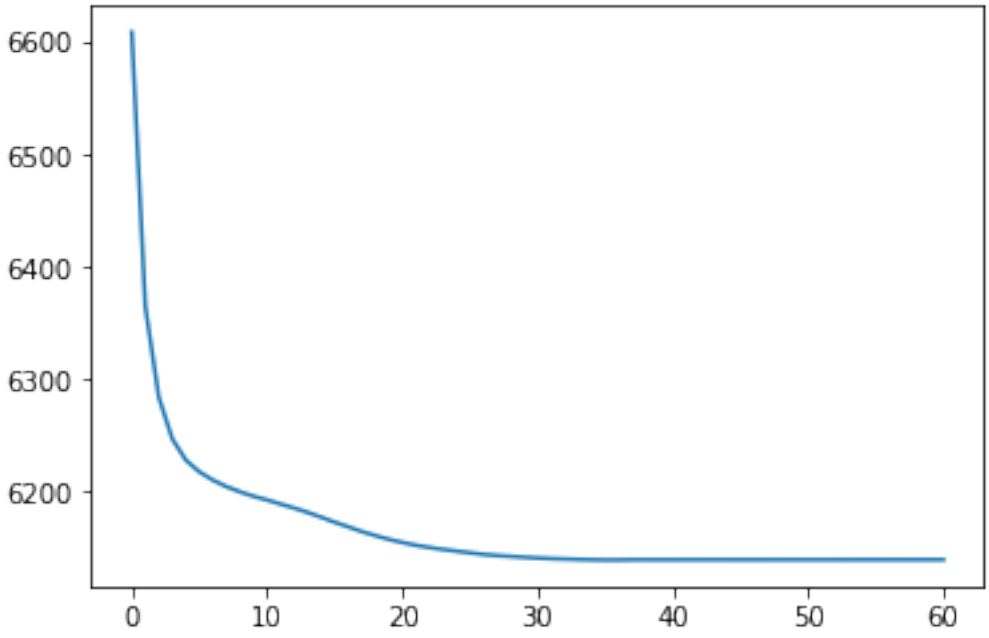
In [17]:
```
# plot final centroid images
plot_centroid_images(centroids)

# plot histories
```

```
plot_centroid_history(acc_hist)
plot_centroid_history(eng_hist)
```






6600
6500
6400
6300
6200
0
10
20
30
40
50
60