Assignment6

May 8, 2019

1 Information

Writer : *Junhyuck Woo*
Std.ID : 20145337
Project : *K − means clustering on the spatial domain*

2 import library

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

3 Global parameter

```
In [2]: size_row = 100       # height of the image
        size_col = 100         # width of the image
```

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

```
In [3]: def normalize(data):

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

            return(data_normalized)
```

5 Function: Distance between two vectors x and y

```
In [4]: def distance(x, y):

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

```
            return(s)
```

6 Function: L2 norm

```
In [5]: def l2_norm(x, y):
            d = (x - y) * (x - y)
            s = np.sum(d)
            r = np.sqrt(s)
            return(r)
```

7 Function: L1 norm

```
In [6]: def l1_norm(x,y):
            d = np.absolute(x-y)
            s = np.sum(d)
            return(s)
```

8 Function: Centroid Combination

```
In [7]: def centroid_combination(centroid, centroid_label):
            result = np.zeros((size_row, size_col, 2), dtype=float)
            for i in range(size_row):
                for j in range(size_col):
                    result[i,j,:] = centroid[:, centroid_label[i,j]]

            return(normalize(result))
```

9 Function: Visualizer

```
In [8]: def visualizer(data, data_label):
            f1 = plt.figure(1)

            plt.title(data_label)
            plt.imshow(data, interpolation='None')

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

            plt.show()
```

10 Function: Initialize Centroid Label

```
In [9]: def initialize_centroid_label(row, col, k):
            centroid_label = np.empty(row*col, dtype=int)

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

            return(centroid_label.reshape((row, col)))
```

11 Function: Calculate Centroid (Average)

```
In [10]: def calculate_average_centroid(row, col, k, train_data, centroid_label):

             centroid = np.zeros((2, k), dtype=float)
             count = np.zeros(k,dtype=int)

             # Create centroid image
             for i in range(row):
                 for j in range(col):
                     index = centroid_label[i,j]
                     centroid[:,index] += train_data[i,j,:]
                     count[index] += 1

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

             return(centroid)
```

12 Function: Calculate Centroid (Median)

```
In [11]: def calculate_median_centroid(row, col, k, train_data, centroid_label):
             x_buf = np.zeros((k, row*col), dtype=float)
             y_buf = np.zeros((k, row*col), dtype=float)
             centroid = np.zeros((2, k), dtype=float)
             count = np.zeros(k, dtype=int)

             for i in range(row):
                 for j in range(col):
                     index = centroid_label[i,j]
                     x_buf[index, count[index]]= train_data[i,j,0]
                     y_buf[index, count[index]]= train_data[i,j,1]
                     count[index]+=1
```

```
            for i in range(k):
                if count[i]==0:
                    centroid[:,i] = np.array([0, 0])
                    continue

                x_centroid = x_buf[i, 0:count[i]]
                y_centroid = y_buf[i, 0:count[i]]


                x_centroid = np.sort(x_centroid)
                y_centroid = np.sort(y_centroid)
                x = x_centroid[int(count[i]/2)]
                y = y_centroid[int(count[i]/2)]
                centroid[:,i] = np.array([x, y])

            return(centroid)
```

13 Function: Clustering Data

```
In [12]: def clustering(row, col, k_num, train_data, centroid, mode):
             cluster_label = np.zeros((size_row, size_col), dtype=int)
             dist = np.zeros(k_num, dtype=float)

             for i in range(size_row):
                 for j in range(size_col):
                     for k in range(k_num):
                         if mode==1:
                             dist[k] = l1_norm(train_data[i,j,:], centroid[:,k])
                         if mode==2:
                             dist[k] = l2_norm(train_data[i,j,:], centroid[:,k])
                     cluster_label[i,j] = np.argmin(dist)

             return(cluster_label)
```

14 Function: Energy

$\frac{1}{n}\sum_{x\in\Omega}\|f(x)-m_c\|^2$
where k_i denotes the category of x_i, and c_{k_i} denotes the centroid of category x_i

```
In [13]: def calculate_energy(row, col, train_data, centroid, centroid_label, mode):
             energy = 0

             for i in range(row):
                 for j in range(col):
                     if mode==1:
                         energy += l1_norm(train_data[i,j,:], centroid[:,centroid_label[i,j]])
                     if mode==2:
```

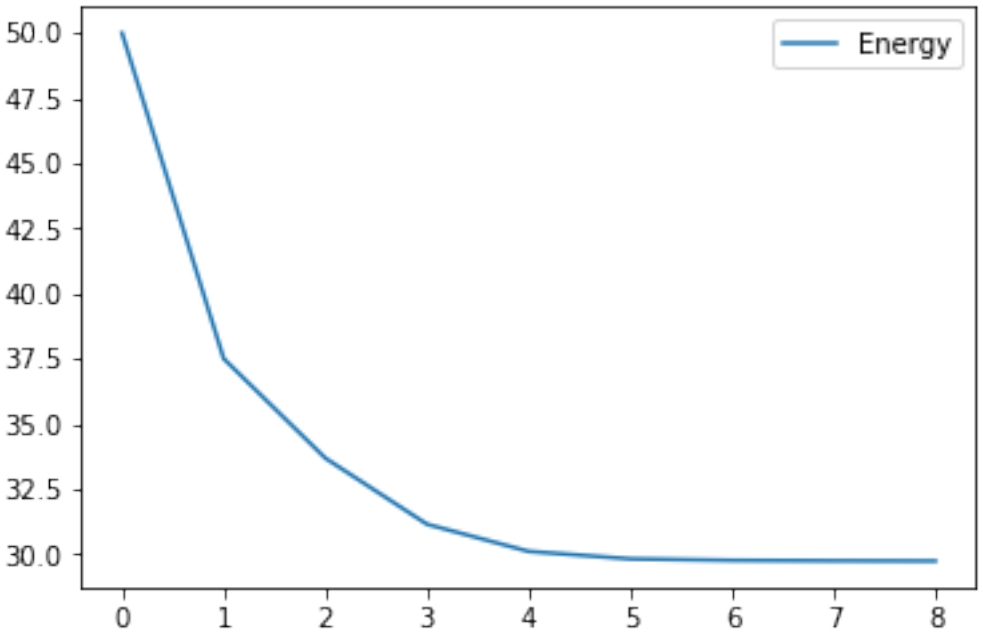
```
                    energy += l2_norm(train_data[i,j,:], centroid[:,centroid_label[i,j]])

        return(energy/(row*col))
```

15 Function: K Means Algorithms

```
In [14]: def k_means(row, col, k, mode):
            train_data = np.zeros((row, col, 2), dtype='f')
            for i in range(row):
                for j in range(col):
                    train_data[i][j][0] = j
                    train_data[j][i][1] = j

            energy = []
            train_accuracy = []

            previous_label = np.zeros((row, col), dtype=int)
            centroid_label = initialize_centroid_label(row, col, k)

            while (~np.all(previous_label == centroid_label)):
                if mode==1:
                    centroid = calculate_median_centroid(row, col, k, train_data, centroid_lab
                if mode==2:
                    centroid = calculate_average_centroid(row, col, k, train_data, centroid_la

                # check traaining energy
                energy.append(calculate_energy(row, col, train_data, centroid, centroid_label
                previous_label = centroid_label
                centroid_label = clustering(row, col, k, train_data, centroid, mode)

            # Visualize K centroid images for each category.
            visualizer(centroid_label,"")

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

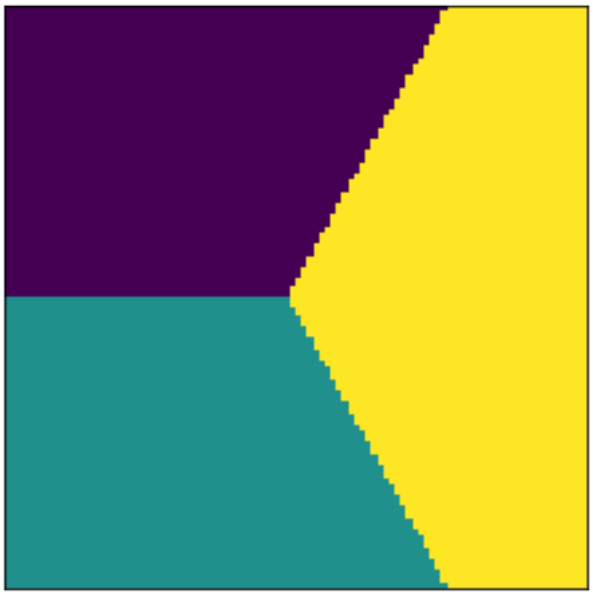
16 k=3 L1-Norm

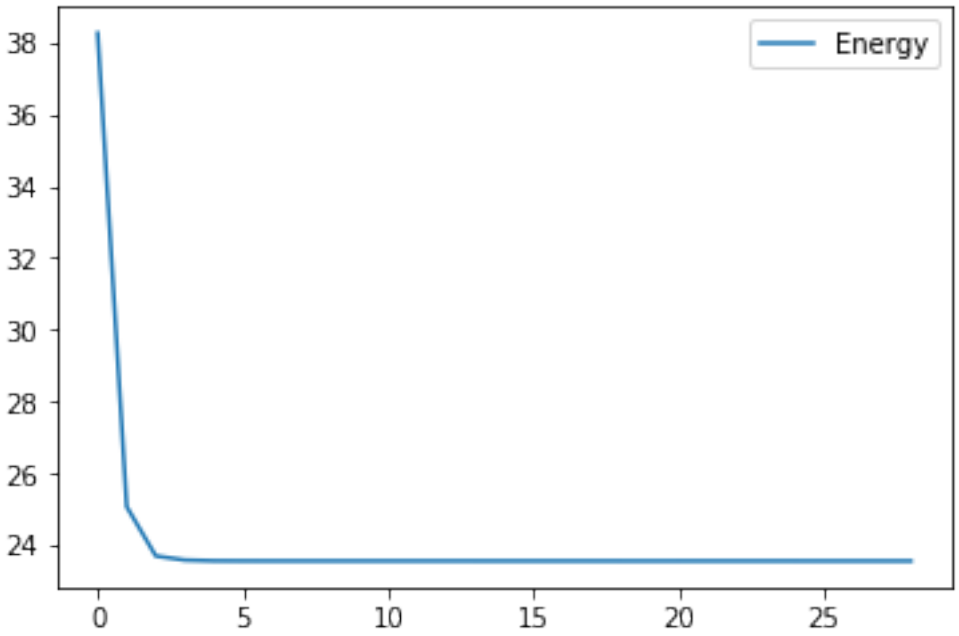
```
In [15]: k_means(size_row, size_col, 3, 1)
```



17 K = 3 L2-norm

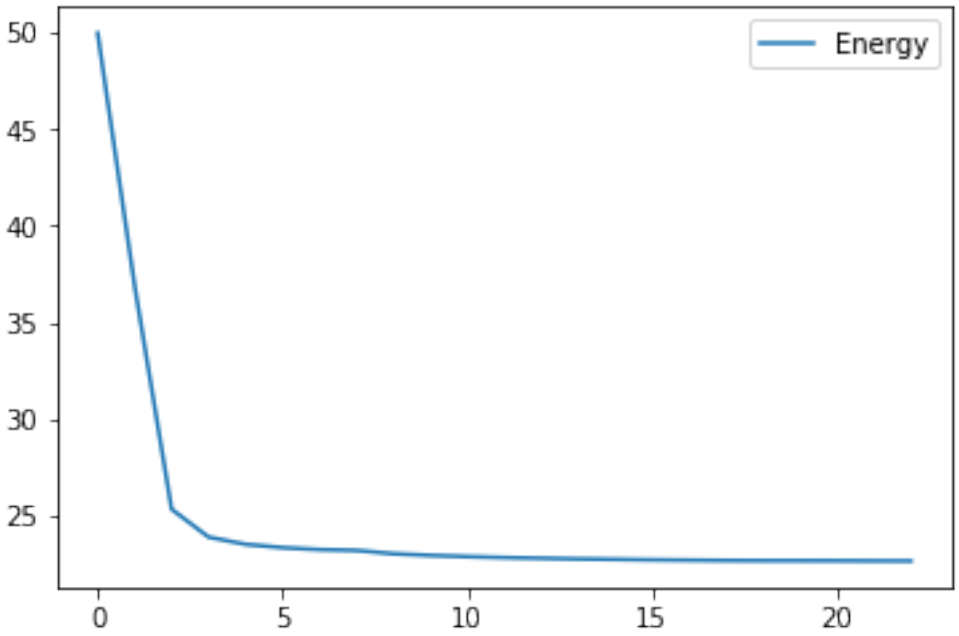
In [16]: k_means(size_row, size_col, 3, 2)





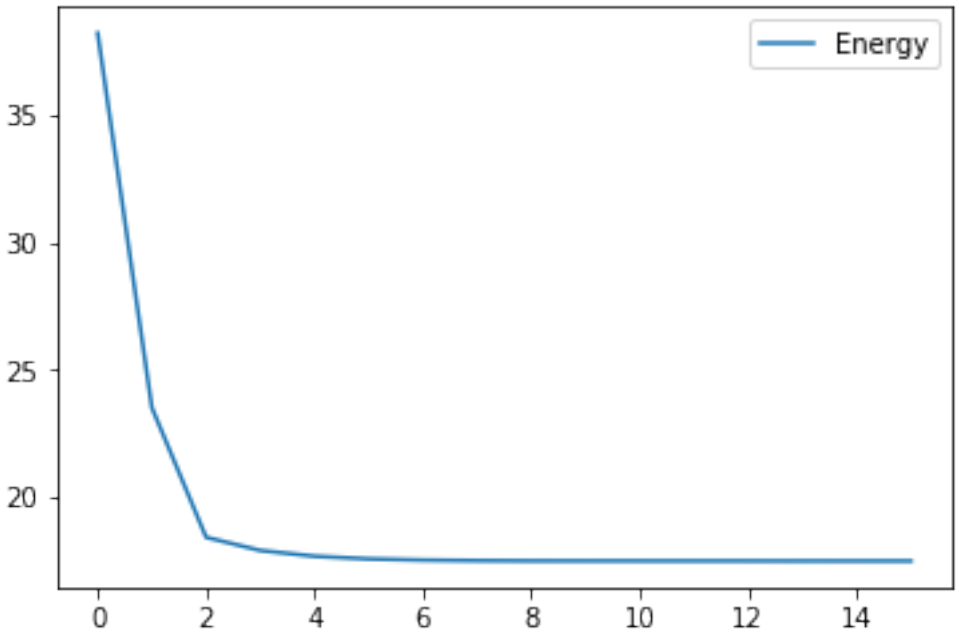
18 K = 5 L1-norm

In [19]: k_means(size_row, size_col, 5, 1)



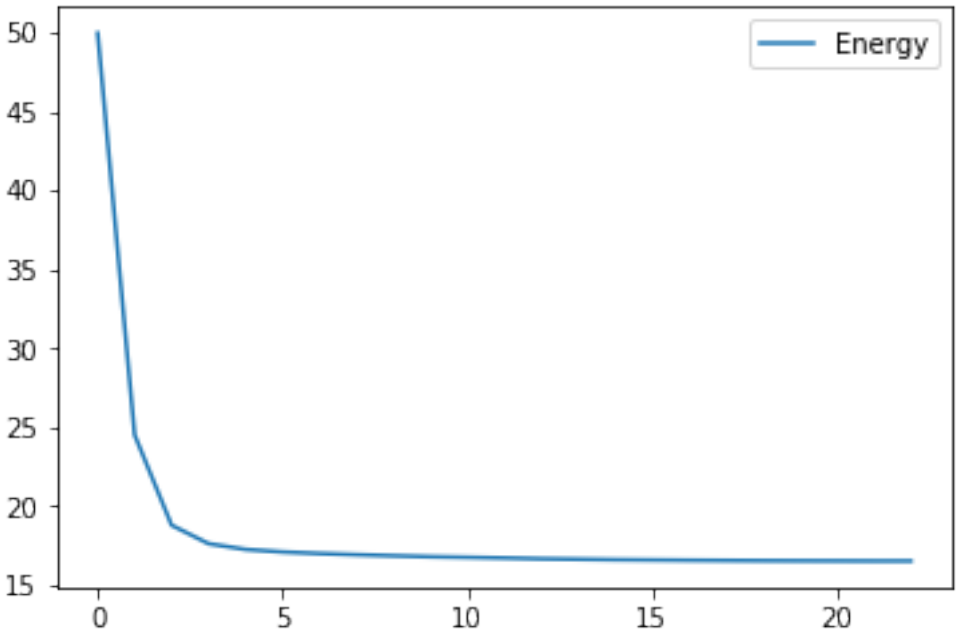
19 K=5 L2-norm

```
In [20]: k_means(size_row, size_col, 5, 2)
```



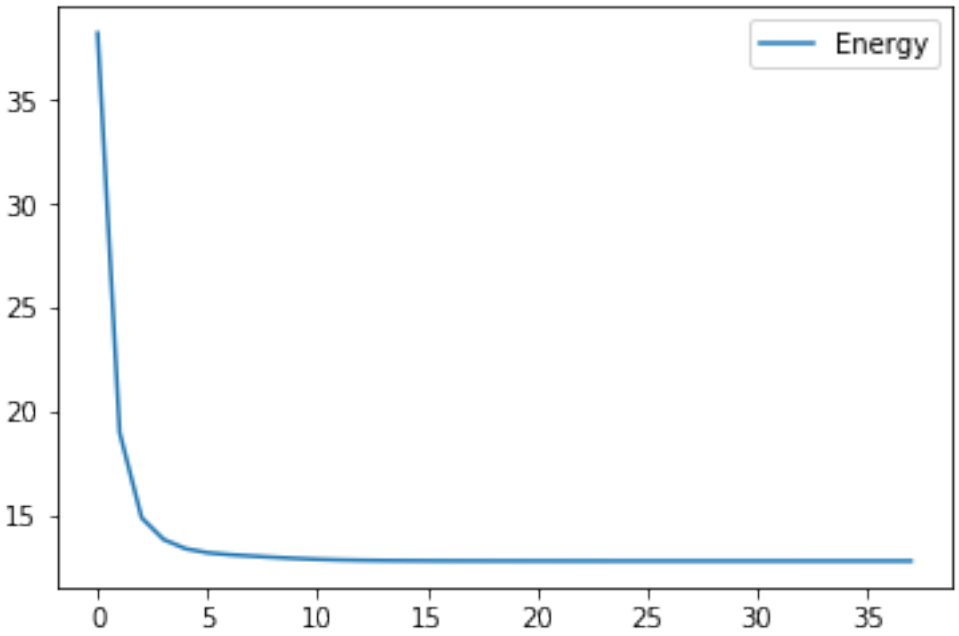
20 K = 9 L1-norm

```
In [21]: k_means(size_row, size_col, 9, 1)
```



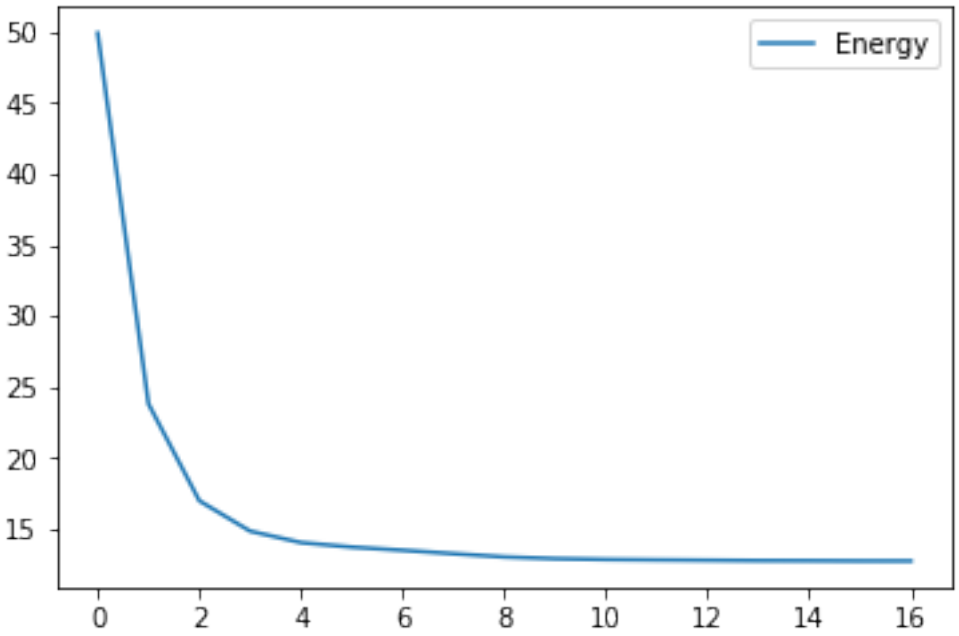
21 k=9 L2-norm

In [22]: `k_means(size_row, size_col, 9, 2)`



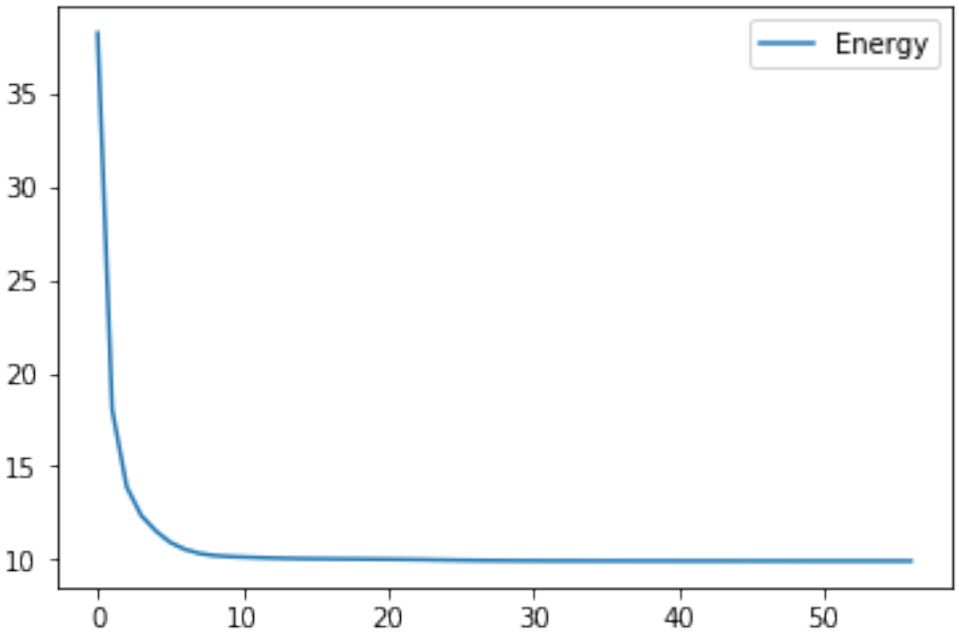
22 K = 15 L1-norm

In [23]: k_means(size_row, size_col, 15, 1)



23 K=15 L2-norm

```
In [24]: k_means(size_row, size_col, 15, 2)
```


Energy
35
30
25
20
15
10
0
10
20
30
40
50