Assignment05

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20164245 Hong Jin

Let $f(x)$ be a color image and x be the index of image in the domain. The values of image $f(x)$ consist of [red, green, blue] intensity.

Apply K-means algorithm to image $f(x)$ based on its color value with given number of clusters K and visualize the progress of optimization and results of the algorithm for each selected number of clusters K.

1 Load Image

```
In [1]: import matplotlib.pyplot as plt
        import numpy as np
        import random
        import cv2

        image = cv2.imread("kong.jpg")
        im_color = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
        height, width = im_color.shape[:2]
        im_label = np.zeros((height, width), dtype = int)
        E = []
```

2 Initial Image

```
In [2]: plt.title('Original Image')
        plt.imshow(im_color)
        plt.axis('off')
        plt.show()
```

3 Nomalization

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

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

            return(data_normalized)
```

4 Compute distance based on L2-norm (x, y)

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

```
In [4]: def distance(x,y):
            d = (x - y) ** 2
            s = np.sum(d)
            r = np.sqrt(s)

            return r
```

5 Initialize Label

initialize all images with random label

```
In [5]: def initialLabel(cluster_num):
            for i in range(height):
                for j in range(width):
                    initial_num = random.randrange(0, cluster_num)
                    im_label[i][j] = initial_num

            return im_label
```

6 Initialize Centroid

```
In [6]: def initialCentroid(im_average, cluster_num, im_label, im_count):
            for i in range(height):
                for j in range(width):
                    im_average[im_label[i,j]] += im_color[i,j]
                    im_count[im_label[i,j]] += 1

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

            return im_average, im_count
```

7 Plot the Final Image

Plot initial and final image

```
In [7]: def plot_average(im_average, im_count, cluster_num):
            f1 = plt.figure(1)
            new_image = im_color.copy()

            for i in range(height) :
                for j in range(width):
                    new_image[i][j] = im_average[im_label[i][j]]

            plt.title('Final Image')
            plt.imshow(new_image)
            plt.axis('off')
            plt.show()
```

8 Clustering

```
In [8]: def clustering(im_label, cluster_num, im_average):
            dist = []
            for i in range(height):
                for j in range(width):
                    dist.clear()
                    for k in range(cluster_num):
                        x = im_color[i,j]
                        y = im_average[k]
                        dist.append(distance(x, y))
                    im_label[i][j] = np.argmin(dist)

            return im_label
```

9 Compute Centroid

```
In [9]: def computeCentroid(cluster_num, im_label):
            num = np.zeros((cluster_num), dtype = int)
            c = np.zeros((cluster_num, 3), dtype = float)

            for i in range(height):
                for j in range(width):
                    c[im_label[i][j]] += im_color[i][j]
                    num[im_label[i][j]] += 1

            for k in range(cluster_num):
                if num[k] != 0:
                    c[k] /= num[k]
            return c
```

10 Compute Energy

$E = \frac{1}{n} \sum_{x \in \Omega} \| f(x) - m_c \|^2$,

where Ω denotes the image domain and the number of pixels $|\Omega|$ is n, and m_c denotes the centroid for cluster c that is the cluster label of $f(x)$.

```
In [10]: def computeEnergy(im_label, cluster_num, im_average):
             total_sum = 0
             num = 0
             for i in range(height):
                 for j in range(width):
                     total_sum += sum((im_color[i,j] - im_average[im_label[i][j]]) ** 2)
                     num += 1

             total_sum /= num
             return total_sum
```

11 Initialize Cluster

```
In [11]: def initialCluster(cluster_num):
             im_average = np.zeros((cluster_num,3), dtype=float)
             im_count = np.zeros(cluster_num, dtype=int)
             im_label = initialLabel(cluster_num)

             im_average, im_count = initialCentroid(im_average, cluster_num, im_label, im_coun

             E.clear()

             return im_average, im_count, im_label
```

12 Clustering until no change

no change means energy is maintained

```
In [12]: def iteration(cluster_num, im_average, im_count, im_label):
             iter_num = 0
             while True:
                 im_label = clustering(im_label, cluster_num, im_average)
                 im_average = computeCentroid(cluster_num, im_label)
                 E.append(computeEnergy(im_label, cluster_num, im_average))

                 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
```

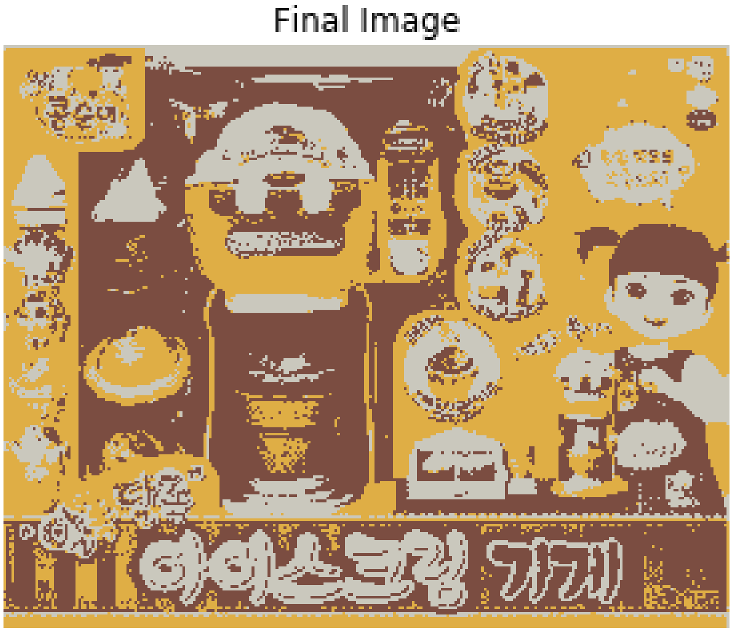
13 Energy graph per each iteration

```
In [13]: 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()
```

14 K = 3

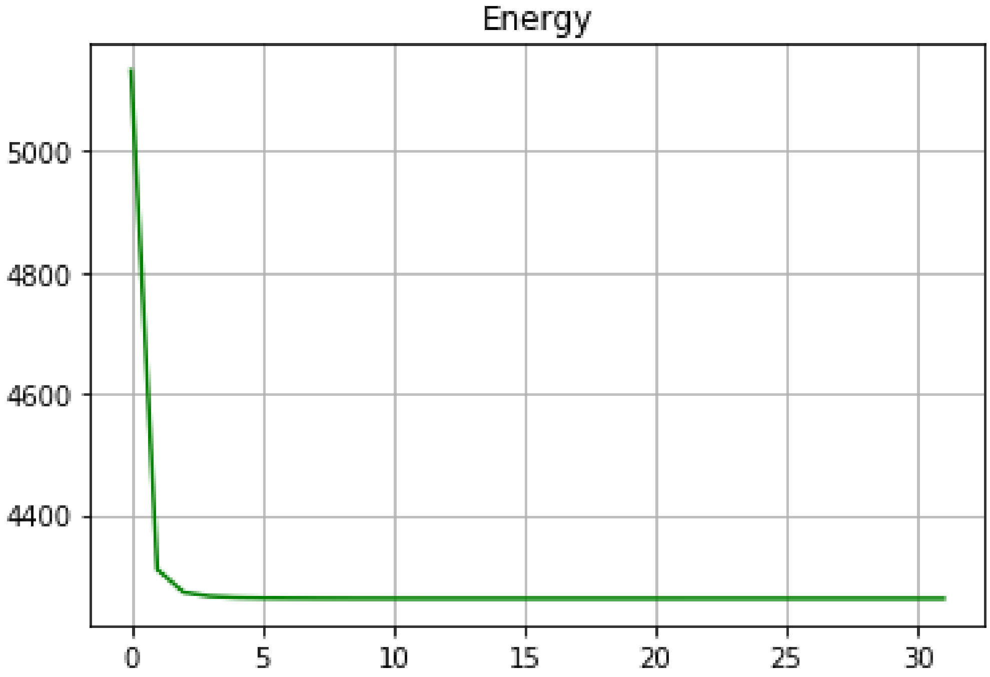
14.1 Final average image

```
In [14]: im_average, im_count, im_label = initialCluster(3)
         iter_num = iteration(3,im_average, im_count, im_label)
```



14.2 Energy graphs

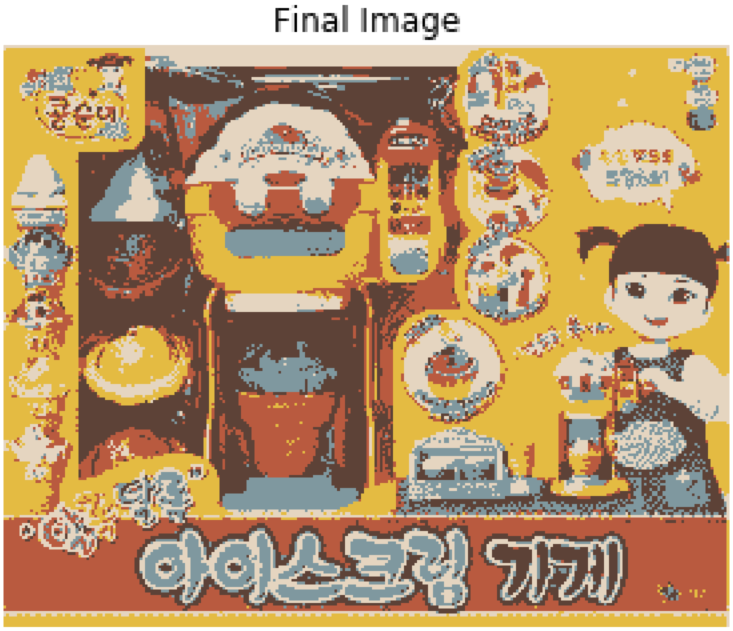
```
In [15]: drawEnergy(iter_num)
```



15 K = 5

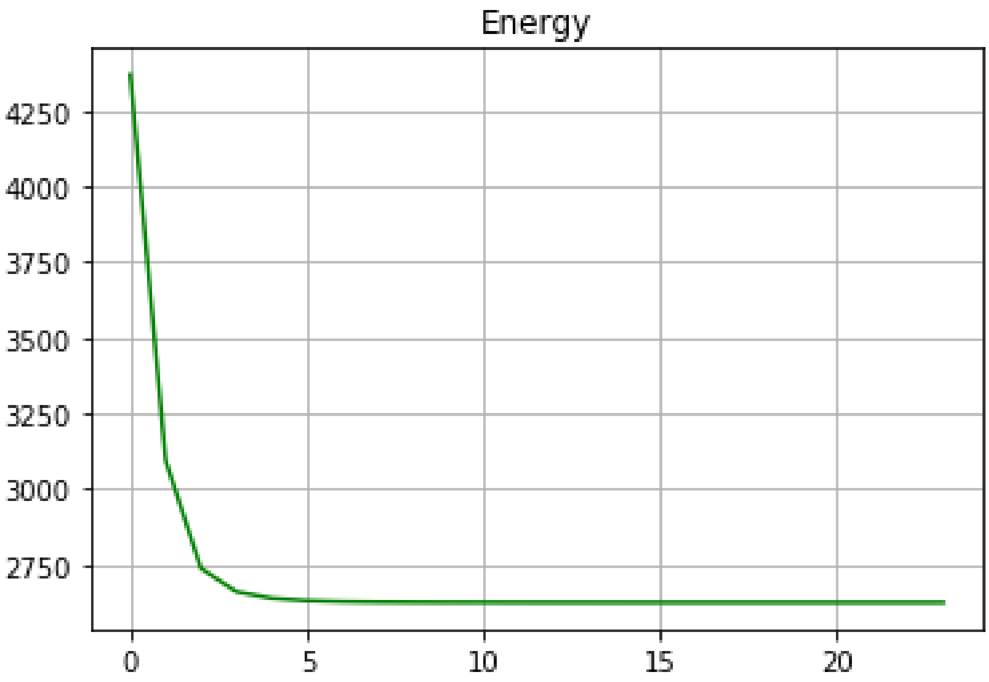
15.1 Final average image

```
In [16]: im_average, im_count, im_label = initialCluster(5)
         iter_num = iteration(5,im_average, im_count, im_label)
```



15.2 Energy graphs

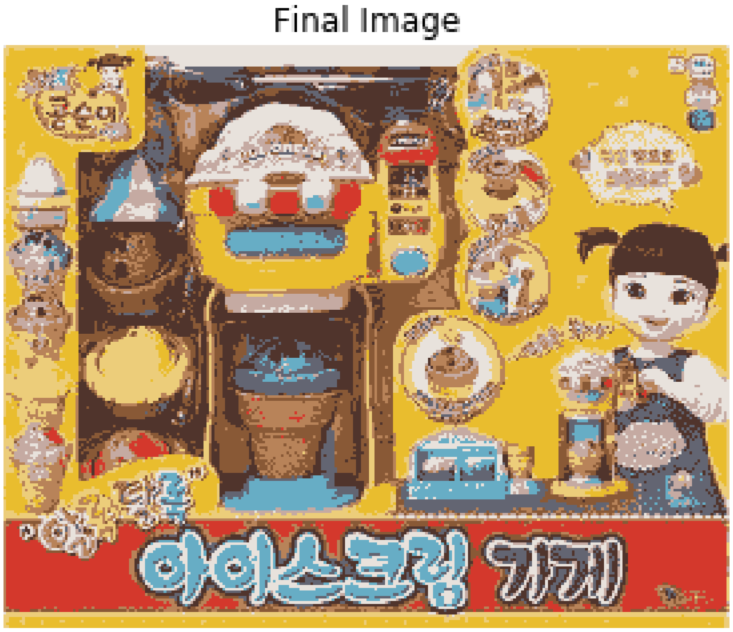
```
In [17]: drawEnergy(iter_num)
```



16 K = 10

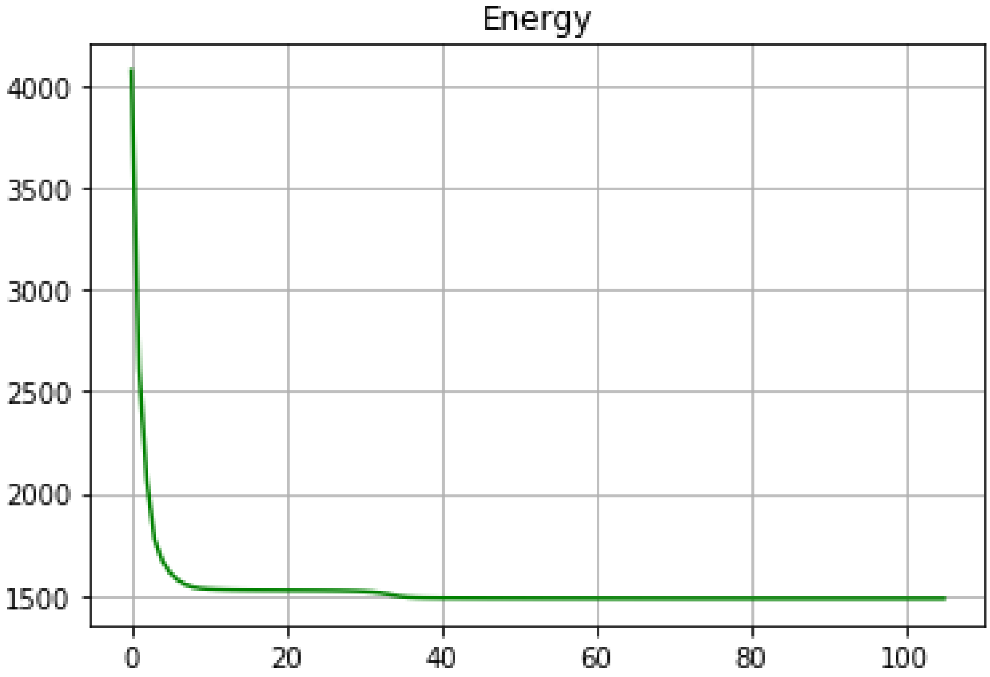
16.1 Final average image

```
In [18]: im_average, im_count, im_label = initialCluster(10)
         iter_num = iteration(10,im_average, im_count, im_label)
```



16.2 Energy graphs

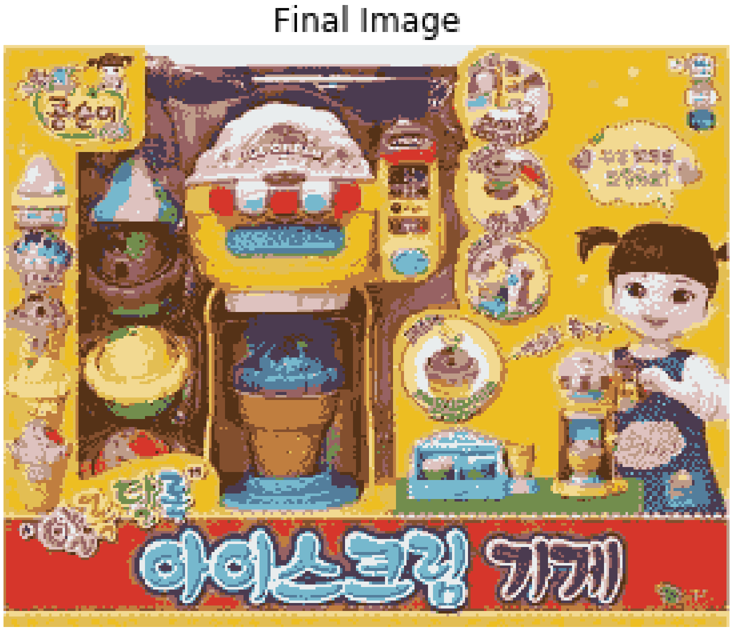
```
In [19]: drawEnergy(iter_num)
```



17 K = 15

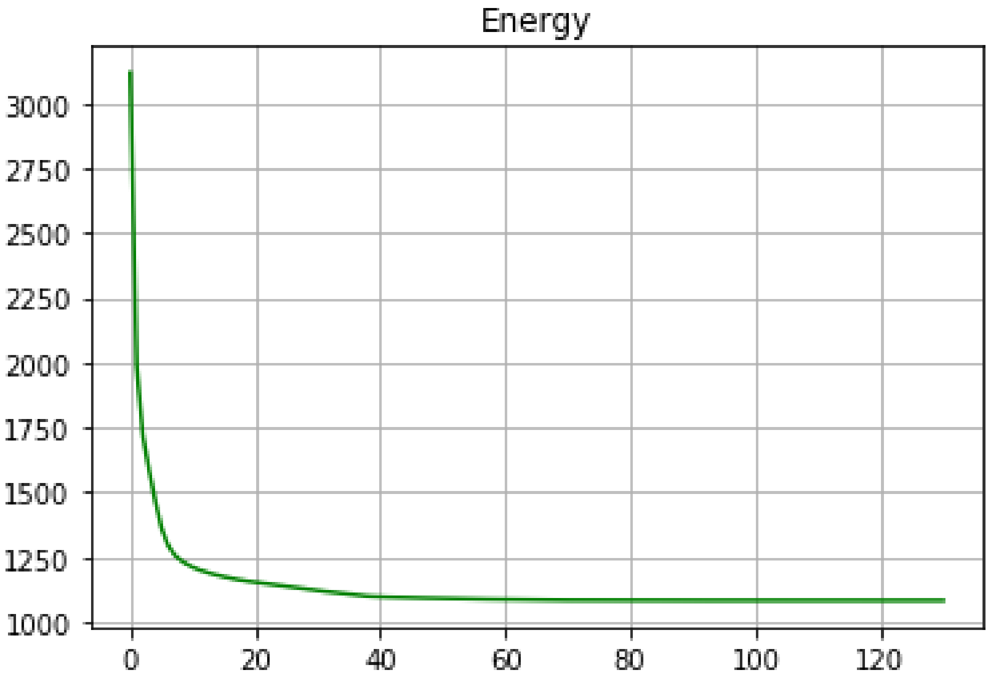
17.1 Final average image

```
In [20]: im_average, im_count, im_label = initialCluster(15)
         iter_num = iteration(15,im_average, im_count, im_label)
```



17.2 Energy graphs

```
In [21]: drawEnergy(iter_num)
```


Energy
3000
2750
2500
2250
2000
1750
1500
1250
1000
0
20
40
60
80
100
120