04_Exercise1_K-means

May 20, 2018

1 Team Members

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2 Task: Image compression with K-means

Implement K-Means algorithm and apply it to compress an image "NAORelease.jpg" for various K (see slides for details). As a feature vector use RGB-representation of each pixel from the image. Analyse running time, what could you suggest to improve it? Compare your implementation with the existing k-mean algorithm given in python.

```
In [17]: from IPython.display import Image
         from datetime import datetime
         Image(filename='NAORelease.jpg')
```

Out[17]:

```
In [2]: import skimage
        from skimage import io
        from sklearn.cluster import KMeans
```

```
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
```

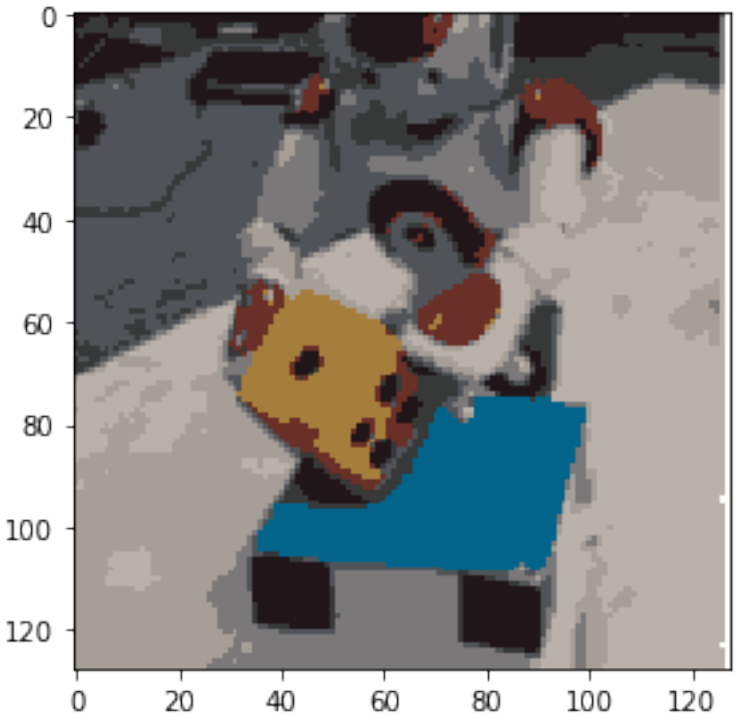
3 K-means using Library

```
In [3]: def ImageCompression(K, iterations):

            load_image = io.imread('NAORelease.jpg')
            image_shape = load_image.shape
            rows = image_shape[0]
            cols = image_shape[1]
            load_image = load_image.reshape(image_shape[0]*image_shape[1],3)

            kmeans = KMeans(n_clusters=K, max_iter=iterations).fit(load_image)

            # find clusters
            clusters = np.asarray(kmeans.cluster_centers_,dtype=np.uint8)
            labels = np.asarray(kmeans.labels_,dtype=np.uint8 )
            labels = labels.reshape(rows,cols)
            return clusters, labels
```

```
In [13]: def ImageDecompression(centers, c_image,image_name):

             image = np.zeros((c_image.shape[0],c_image.shape[1],3),dtype=np.uint8 )
             for i in range(c_image.shape[0]):
                 for j in range(c_image.shape[1]):
                         image[i,j,:] = centers[c_image[i,j],:]
             io.imsave(image_name,image);
             io.imshow(image)
             io.show()
```

4 K = 10, Max Iterations = 30

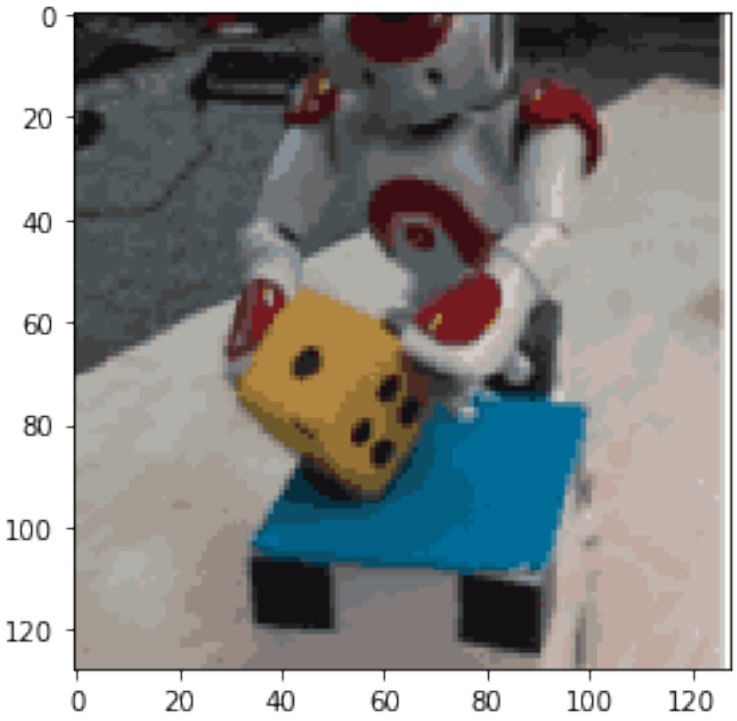
```
In [18]: start=datetime.now()
         K = 10
         iterations = 30
         clusters, labels = ImageCompression(K, iterations)
         np.save('codebook_robot_k10.npy', clusters)
         io.imsave('compressed_robot_k10.png',labels)
         centers = np.load('codebook_robot_k10.npy')
         c_image = io.imread('compressed_robot_k10.png')
         ImageDecompression(centers, c_image,'reconstructed_robot_k10.png')
         print datetime.now()-start
```




```
0:00:00.550001
```

5 K = 30, Max Iterations = 30

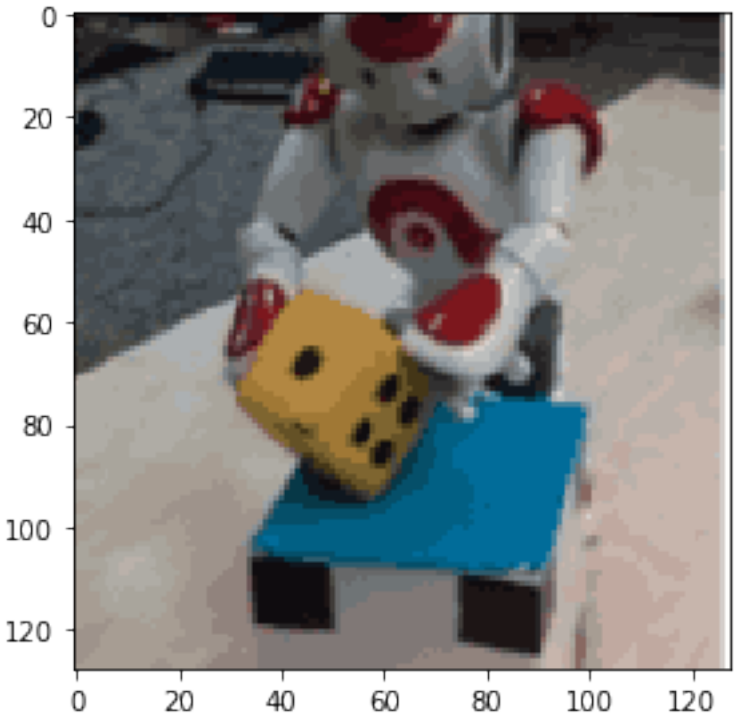
```
In [19]: start=datetime.now()
         K = 30
         iterations = 30
         clusters, labels = ImageCompression(K, iterations)
         np.save('codebook_robot_k30.npy', clusters)
         io.imsave('compressed_robot_k30.png',labels)
         centers = np.load('codebook_robot_k30.npy')
         c_image = io.imread('compressed_robot_k30.png')
         ImageDecompression(centers, c_image,'reconstructed_robot_k30.png')
         print datetime.now()-start
```



0:00:01.531720

6 K = 50, Max Iterations = 30

```
In [20]: start=datetime.now()
         K = 50
         iterations = 30
         clusters, labels = ImageCompression(K, iterations)
         np.save('codebook_robot_k50.npy', clusters)
         io.imsave('compressed_robot_k50.png',labels)
         centers = np.load('codebook_robot_k50.npy')
         c_image = io.imread('compressed_robot_k50.png')
         ImageDecompression(centers, c_image,'reconstructed_robot_k50.png')
         print datetime.now()-start
```



0:00:02.689913

7 K-Means using Algorithm(without Library)

```
In [83]: class Cluster(object):
             def __init__(self):
                 self.pixels = []
                 self.centroid = None

             def addPoint(self, pixel):
                 self.pixels.append(pixel)

             def setNewCentroid(self):
                 R = [colour[0] for colour in self.pixels]
                 G = [colour[1] for colour in self.pixels]
                 B = [colour[2] for colour in self.pixels]

                 R = sum(R) / len(R)
                 G = sum(G) / len(G)
                 B = sum(B) / len(B)

                 self.centroid = (R, G, B)
```

```
                self.pixels = []

                return self.centroid
```

In [84]:
```
class Kmeans(object):

    def __init__(self, K, max_iterations):
        self.K = K
        self.max_iterations = max_iterations

    def run(self, image):
        self.image_size = image.size
        self.pixels = np.array(image.getdata(), dtype=np.uint8)
        self.clustered_pixels = [None] * len(image.getdata())
        self.clusters = []

        #pick random centroid for each K
        randomCentroids = random.sample(self.pixels, self.K)

        for idx in range(self.K):
            self.clusters.append(Cluster())
            self.clusters[idx].centroid = randomCentroids[idx]

        iteration = 0
        while iteration < self.max_iterations:
            for idx, pixel in enumerate(self.pixels):
                self.assignClusters(idx, pixel)

            for cluster in self.clusters:
                cluster.setNewCentroid()

            iteration += 1

        return

    def assignClusters(self, idx, pixel):
        shortest_distance = float('Inf')
        for cluster in self.clusters:
            curr_distance = self.calcDistance(cluster.centroid, pixel)
            if curr_distance < shortest_distance:
                shortest_distance = curr_distance
                nearest = cluster

        nearest.addPoint(pixel)
        self.clustered_pixels[idx] = nearest.centroid

    #distance is calculated by taking sum abs diff from each pixel (RGB)
    #then normalize it
```

```
    def calcDistance(self, a, b):
        result = (sum(abs(a-b)))/3.0
        return result

    #show clustered_pixels
    def showClusteredPixels(self):
        w, h = self.image_size
        self.clustered_pixels = np.asarray(self.clustered_pixels).astype('uint8').resh
        colourMap = Image.fromarray(self.clustered_pixels)
        colourMap.show()
```

8 K = 10, Max Iterations = 30

```
In [86]: import random
         # import Image
         from PIL import Image
         start=datetime.now()
         K = 10
         max_iterations = 30
         k_means = Kmeans(K, max_iterations)
         img = Image.open("NAORelease.jpg")
         k_means.run(img)
         print datetime.now()-start
```

```
0:01:09.658876
```

```
In [47]: k_means.showClusteredPixels()
```

```
In [63]: Image(filename='kMeans10K.png')
```

Out[63]:

9 K = 30, Max Iterations = 30

```
In [87]: start=datetime.now()
         K = 30
         max_iterations = 30
         k_means = Kmeans(K, max_iterations)
         img = Image.open("NAORelease.jpg")
         k_means.run(img)
         print datetime.now()-start
```

```
0:03:16.147051
```

```
In [75]: k_means.showClusteredPixels()
```

```
In [81]: Image(filename='kMeans30K.png')
```

Out[81]:

10 K = 50, Max Iterations = 30

```
In [90]: start=datetime.now()
         K = 50
         max_iterations = 30
         k_means = Kmeans(K, max_iterations)
         img = Image.open("NAORelease.jpg")
         k_means.run(img)
         print datetime.now()-start
```

```
0:05:21.823218
```

```
In [91]: k_means.showClusteredPixels()
```

```
In [95]: from IPython.display import Image
         Image(filename='kMeans50K.png')
```

Out[95]:

11 Runtime analysis

We observed that, Kmeans algorithm from sklearn library consumes very less runtime than our implementation. For example, sklearn library took 1.531720 seconds to compress the image (k=30) and our implementation took 3 minutes and 16 seconds to compress the image (k=30).

It shows that, sklearn library is faster than our implementation.

In terms of compressed image size, our implementation reduced the image size much smaller than the sklearn compressed image size.