DATA_301_Assignment_7B_Ishaan_Sathaye_Sreshta_Talluri

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1 Image Compression Using Clustering

Let's learn how to use clustering to compress images. Each image consists of n pixels, where n is a large number. Each pixel contains a value between 0-255 for each of the 3 color channels: red, blue, and green (RGB). Each of these numbers can be represented using $\log_2 256 = 8$ bits, so it takes 24 bits to represent each pixel and $24n$ bits to represent the entire image.

Now, suppose we treat each of the n pixels as a 3-dimensional point (the three values R, G, and B), and we cluster these n points into k clusters, where k is much smaller than n. Since each point should be close to the center of the cluster, we can replace the color of each pixel by the color of its cluster centroid. Now we only have to store which cluster each pixel belongs to, which requires $n \log_2 k$ bits, plus a codebook that maps each of the k centroids to RGB values, which requires \$ 24 k\$ bits. So in total, we have reduced the size of the image from:

$$24n \longrightarrow n \log_2 k + 24k.$$

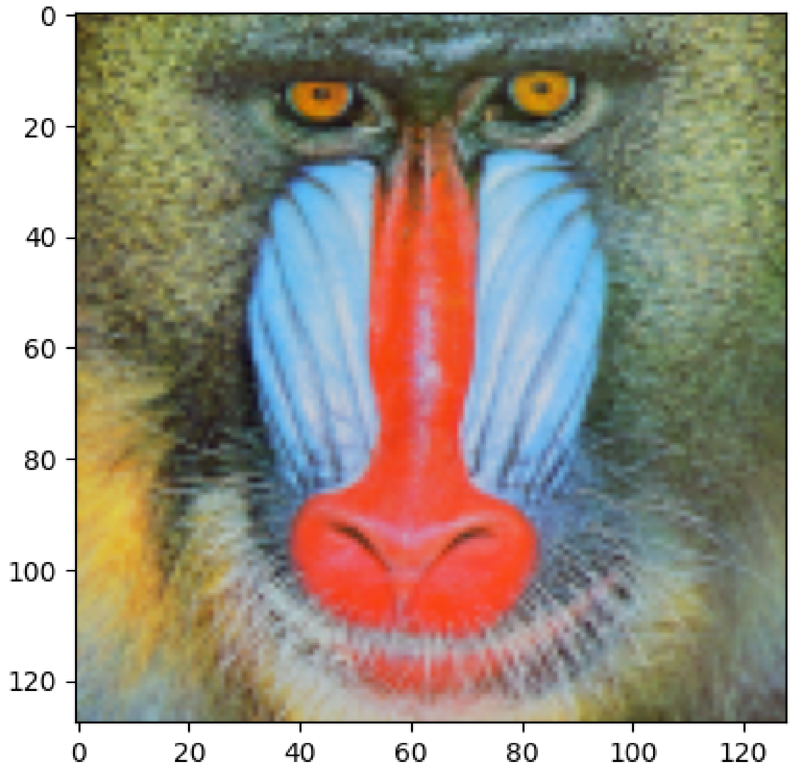
The code below reads in a 128 x 128 image of a baboon. So in this case, $n = 128 \times 128 = 16384$. We will cluster these 16384 observations into just $k = 16$ clusters. So we will compress the image from $24 \cdot 16384 = 393216$ bits to $16384 \log_2 16 + 24 \cdot 16 = 65920$ bits, by a factor of 6. This technique of using clustering to compress data is known as **vector quantization**.

Some code to read in and display an image is provided below. In the code below, `image` is a 16384 x 3 array of integer values. Each row represents the R, G, and B intensities of one of the pixels in a 128 x 128 image. To view the image, we have to first reshape the data to be 3-dimensional (128 x 128 x 3) and then call the function `plt.imshow()`.

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

image_df = pd.read_table("https://dlsun.github.io/pods/data/mandrill.rgb",
                         sep=" ", header=None, names=["r", "g", "b"])
image_array = image_df.values.astype("uint8")
plt.imshow(np.reshape(image_array, (128, 128, 3)))
```

[1]: <matplotlib.image.AxesImage at 0x11fca1ac0>



Now let's compress the image. The 16384 pixels contain over 16000 distinct colors. We'll reduce the number of colors to just 16. To do this, we will cluster the 16384 RGB values into $k = 16$ clusters using k-means clustering. The centroid of each cluster will be a color that should be "close" to the color of the pixels in the cluster. Thus, we can replace the color of each pixel by the color of the cluster centroid.

Run k-means clustering. Note that you should be applying k-means clustering to the original (16384, 3) 2D array, and not the reshaped 3D array. Then, view the compressed image. Since your cluster centroids will be floats, not integers, you may have to cast the RGB values of the centroids to integers using `.astype("uint8")`. You will also have to reshape the image. The image should look similar to the original image, but less crisp. If the colors are seriously distorted, then check your work; chances are that you did something wrong.

[4]:
```
# ENTER YOUR CODE HERE. ADD AS MANY CELLS AS NEEDED
from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters=16, random_state=42)
kmeans.fit(image_array)

compressed_image_array = kmeans.cluster_centers_.astype("uint8")[kmeans.labels_]

compressed_image_array_reshaped = np.reshape(compressed_image_array, (128, 128,
    3))
```

```python
plt.figure(figsize=(10, 5))
plt.imshow(compressed_image_array_reshaped)
plt.title(f'Compressed Image')
plt.show()
```

```
/Users/ishaansathaye/Library/Python/3.9/lib/python/site-
packages/sklearn/cluster/_kmeans.py:1416: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
```