Homework -1
COSC 6373 Computer Vision – Spring 2018
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INTRODUCTION

Computer Vision
Computer Vision is the science that gives ability to a machine to analyze and understand useful information from a single image or a sequence of images.

Segmentation
Image segmentation is the process of partitioning a digital image into multiple segments of pixels. The goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze.

K- Means Algorithm
The objective of this algorithm is to create ‘k’ clusters in the input data. The input data does not have any labels.
Step 1 : Choose the initial ‘k’ cluster centres randomly in the data set. These are pixel intensity and RGB values in the image.
Step 2 : For each pixel assign the closest cluster centre.
Step 3 : Re compute the new cluster centres, by taking the mean of all the pixels in each cluster, and make them the new cluster centers.
Step 4: Repeat steps 2&3 until the cluster centres don’t change or until maximum number of iterations have been reached.
Step 5 : Assign the cluster centre value to every pixel in the cluster output the segmented image.

IMPLEMENTATION

Grey Scale Segmentation

1) Randomly choose different initial intensity pixels.
2) Construct a centroid Map that holds the cluster label for every pixel.
3) Choose the best centroid for every pixel. Calculate the difference in intensity between every centre and the pixel. Assign the centre which has the least difference to the pixel in the Centroid Map.
4) Now after performing the above operation for every pixel. Recalculate the centres based on these clusters.
5) Calculate the mean value of all the pixel intensities in the cluster and assign it as the new cluster centre value.
6) Perform steps 3 through 5 until the algorithm converges.

Color Segmentation

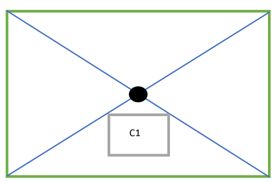
1) Randomly choose different initial intensity pixels but for all the three channels R,G,B.
2) Construct a centroid Map that holds the cluster label for every pixel.
3) Choose the best centroid for every pixel. Now instead of subtracting the intensity values, we need to find the Euclidean distance since there are 3 values.
   Let $px(x_1,y_1,z_1)$ be a pixel and the Cluster centre $C1(x,y,z)$.

The distance between them would be $\sqrt{(x_1 - x)^2 + (y_1 - y)^2 + (z_1 - z)^2}$

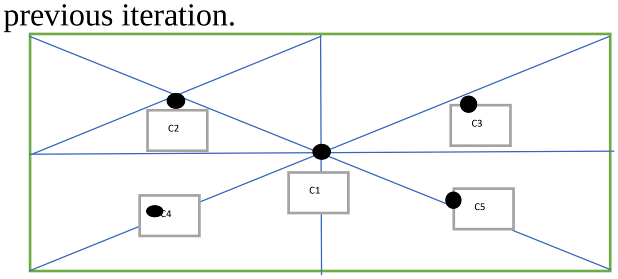
4) Now , calculate the mean for all the 3 channels of every pixel in the cluster and assign each cluster centre with this value.
5) Perform steps 3 through 5 until the algorithm converges.

Points To Note – Thoughts Of Inference

1) Instead of assigning the initial cluster centres randomly, we can follow other models. I have come up with a model theoretically.
   Calculate the centre pixel in the image(the intersection of the diagnols). Now, we can divide the space into four parts (length/2 and width/2). For every subsection, consider the intersection of the diagnols. Repeat this method until we have the required number of cluster centres.
   For every division into subsections we have i*4 + 1. Here, the value of i is the number of cluster centres in the previous iteration.



Iteration 1



Iteration 2

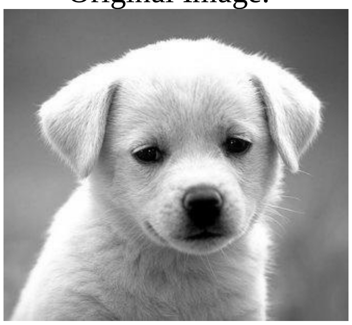
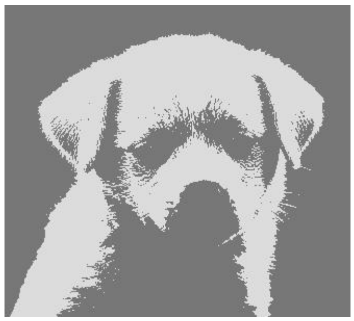
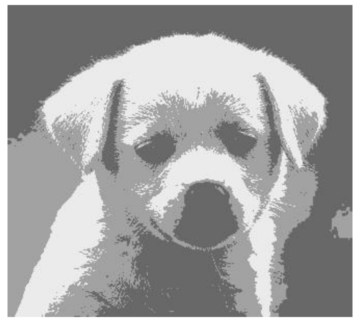
For iteration 1 points = 1, for iteration 2, points = 1*(4) + 1 = 5, and so on.

2) Converging condition can be when the cluster centres of two iterations are same. It means that there is no change in the assignment of pixels to the clusters. And we can stop. We can also limit it to a maximum number of iterations.
3) The centroid Map chosen here for the RGB segmentation is a 3 dimensional list that stores all the values of r,g,b for every pixel in the 2 dimensional image.
4) When we are computing the Euclidean distance in the greyscale image it's a 2 dimensional space. And we get circles(ellipses) as the clusters. But in the RGB 3 dimensional space it is a sphere. And the centre of the sphere is the cluster centre with all the pixels of that cluster in the form of a sphere around it.
5) Calculating the pixel intensity in the RGB space can also be done by assigning weights to the individual r,g and b values.
   We can consider pixel intensity = R value * 65536 + G value * 256 + B value
6) Parameters Influencing the algorithm are
   a) Initial cluster centroids value. If the clusters are random then different segments may be generated with each run. And the convergence also takes time and there is a risk of reaching the local minima and not the global minima. So for a given K we might get different segments with each run. We can run it multiple times to see the output.
   b) Distance calculation method
      If I used a normal subtraction method, the results are not optimal. I tried using the pixel intensity value as well. But the best results with perfect segments were only generated with the Euclidian distance.

7) Color performs better because it is not the intensity of just one channel (intensity of the pixel) but the intensities of 3 channels. The main objective of segmentation- to distinguish the segments in the image is better achieve with color segmentation, since most of the data in the real world is in the form of multiple colors and not grey scale. Color segments can be visualized better by humans. And if we look at it in a machine point of view, most of the data that machines deal with is real time color images.

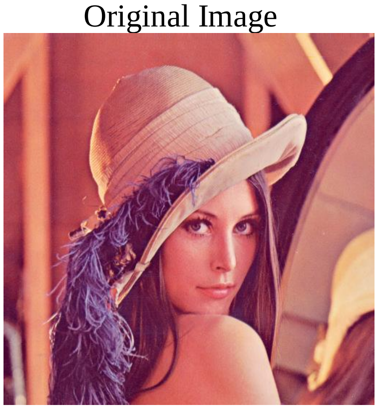
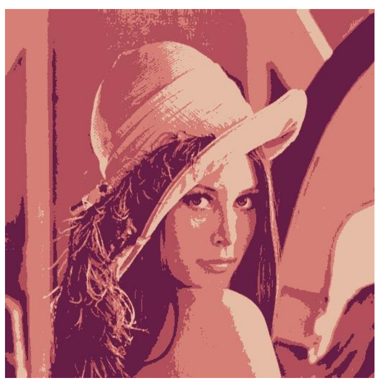
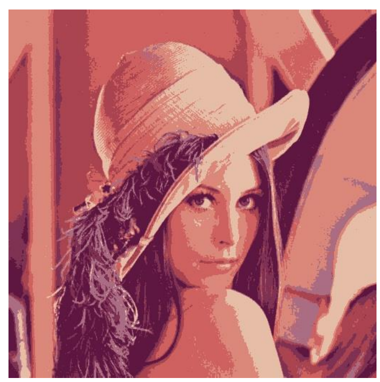
RESULTS

Greyscale

Original Image.	K = 2 clusters.	K = 3 clusters
		

As the number of clusters increase, the image looks more like the original.

Color Segmentation

Original Image	k = 4 clusters	k = 7 clusters
		

In color images along with intensity, there are different shades of color as well.