Final Project
CS 563 IMAGE ANALYSIS
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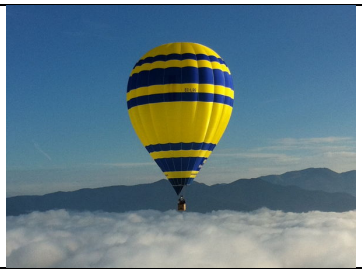
Objective of the program:

The objective of this program is to implement the Mean Shift technique on a colored-image for segmentation.

Summary about the program implemented:

- The code was implemented on **Python version 2.7**
- **The code is not using any library for applying the MeanShift Algorithm**.
- **How it works:** the program gives the user the choice to select among the 4 below listed images: image1.pgm (AirShip), image2.pgm (Island), image3.pgm (Bears) and image4.pgm (Fruits).

<table>
<tr><td>  </td><td>  </td></tr>
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- After that, the program asks the user to enter value of Hr (Range Domain). This will be used to select the neighborhood pixels whose Range Domain Value [r,g,b] are less than Hr.
- The program is by default setting the bandwidth value of the Gaussian kernel to be equal to Hr.
- Below is the description of the algorithm being applied inside the code.

The Meanshift Algorithm (being applied in the code)

We need a few things before we start to run Meanshift on a set of datapoints *X*:

1 A function *N(x)* to determine what are the neighbours of a point $x \in X$. The neighbouring points are the points within a certain distance. The distance metric is usually Euclidean Distance.

2 A kernel *K(d)* to use in Meanshift. K is usually a Gaussian Kernel, and d is the distance between two datapoints.

Now, with the above, this is the Meanshift algorithm for a set of datapoints *X*:

1 For each datapoint $x \in X$, find the neighbouring points *N(x)* of *x*.

2 For each datapoint $x \in X$, calculate the ***mean shift*** *m(x)* from this equation:

$$m(x) = \frac{\sum_{x_i \in N(x)} K(x_i - x) x_i}{\sum_{x_i \in N(x)} K(x_i - x)}$$

3 For each datapoint $x \in X$, update $x \leftarrow m(x)$.

4 Repeat 1. for *n_iteations* or until the points are almost not moving or not moving.

The most important piece is calculating the mean shift *m(x)*. The formula in step 2. looks difficult but let's break it down. Notice the red red encircled parts are essentially the same:

$$m(x) = \frac{\sum_{x_i \in N(x)} K(x_i - x) x_i}{\sum_{x_i \in N(x)} K(x_i - x)}$$

Let's replace that with W_i, so the formula becomes this:

$$m(x) = \frac{\sum_i \mathbf{W_i}\, x_i}{\sum_i \mathbf{W_i}}$$

Look at the general formula for weighted average in Wikipedia gives us this:

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i},$$

Which is just the same thing! Essentially, the meanshift is just calculating **the *weighted average* of the affected points w.r.t. to *x***. From this perspective, the formula can be applied easily.

Approach

Decision Making:

As running the meanShift algorithm take lots of time (hours) by passing into each pixel, getting its neighborhood and applying meanshift technique on it to have the final output. Some solution (taking less than a minute) has been adopted yielding a very satisfactory result.

Such solution is as follows:

- At the beginning, the program extract Feature Matrix from the image [r,g,b,x,y]
- Then, it randomly selects a seed (random pixel) from the feature matrix.
- Then, it gets all the neighbourhood pixels for this seed whose range values are less than Hr value
- Then, it applies meanShift algorithm for this seed along with its neighbors.
- The new meanShift value outputted form above iteration will be assigned to this seed and its neighbor.
- Then the program, will remove this seed and all of its neighbor from Feature Matrix.
- Step 2 till 6 is repeated until the feature matrix is exhausted.

Segmented Result:

image2.pgm (Island)

Original

Segmented: Number of clusters formed : 9 , with Hr=90

Color Distribution of the Segmented Image: Number of clusters formed: 9 , with Hr=90

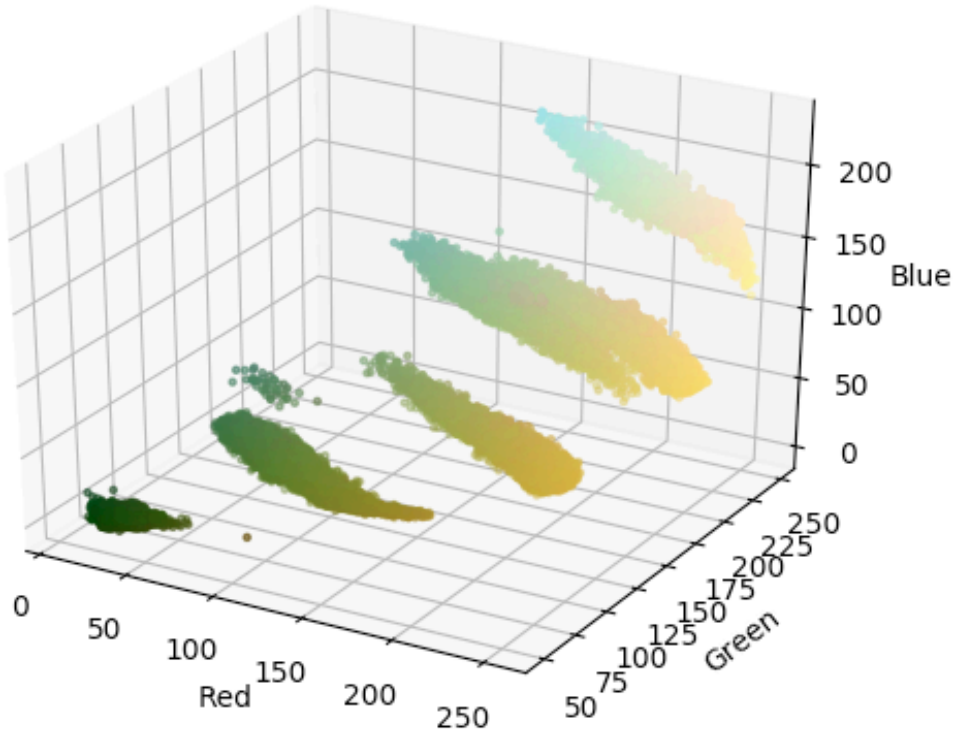

image3.pgm (Bears)

Original

Segmented: Number of clusters formed : 33 , with Hr=40

Color Distribution of the Segmented Image: Number of clusters formed: 33 , with Hr=40

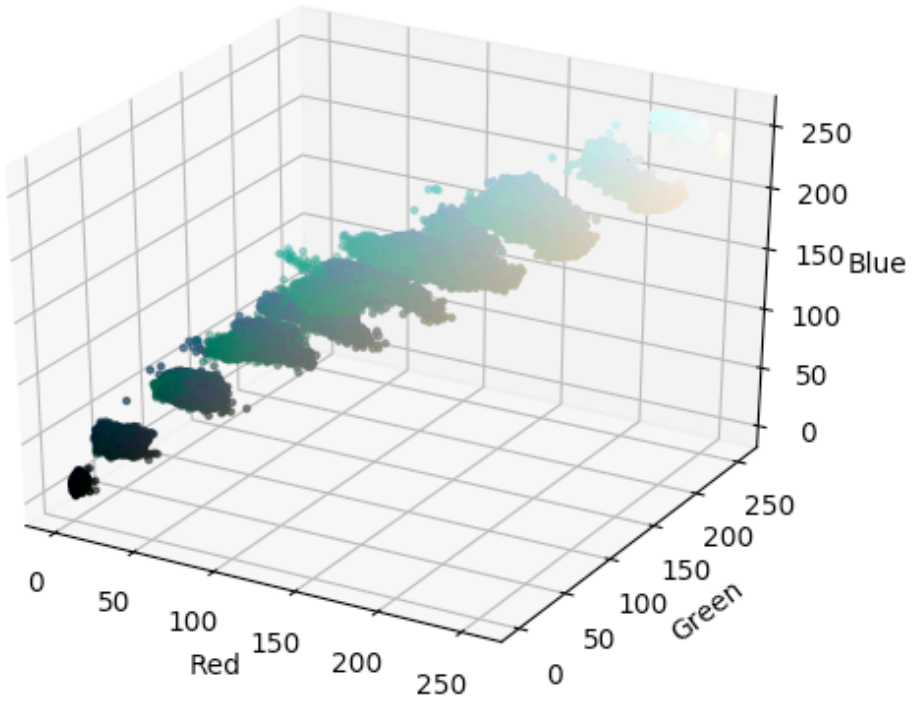

Image4.pgm (Fruits)

Original

Segmented: Number of clusters formed : 14 , with Hr=80

Color Distribution of the Segmented Image: Number of clusters formed: 14 , with Hr=80

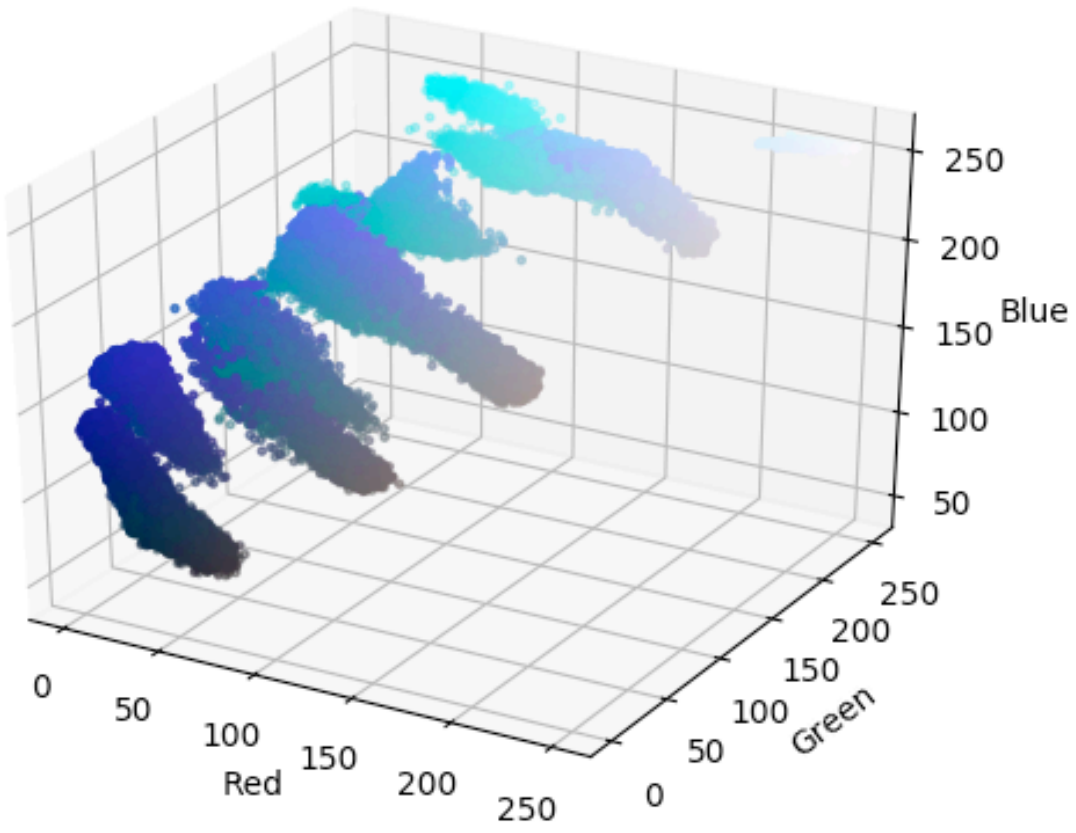

Image1.pgm (AirShip)

Original

Segmented: Number of clusters formed : 26 , with Hr=50

Color Distribution of the Segmented Image: Number of clusters formed: 26 , with Hr=50