S.M.N.D.Dissanayake

130138H

EN4553 - Machine Vision

Project 3

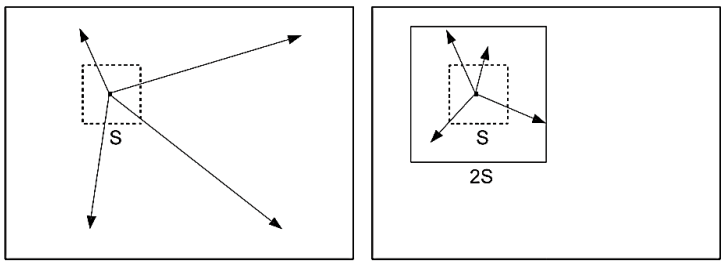
SLIC super-pixels and K-means clustering

1. SLIC super-pixels

SLIC (Simple Linear Iterative Clustering) is a simple and efficient method to decompose an image in visually homogeneous regions(super-pixels). It is based on a spatially localized version of k-means clustering. In this project VLFeat's (Vision Lab Features Library) SLIC segmentation functionality was used to obtain the super-pixel image from any given image.

VLFeat's SLIC function takes two parameters, the "regionSize" and the "regularizer". "regionSize" is the nominal size of the regions (super-pixels) and the "regularizer" is the strength of the spatial regularization.

SLIC starts by dividing the image into a regular grid spaced, S pixels apart. Then a region (super-pixel) is initialized from each grid center. And the centers are moved to locations corresponding to the lowest gradient position in a 3 x 3 neighborhood. This is done to avoid centering a super-pixel on an edge. Then the regions are obtained by running K-means clustering, started from the centers. K-means clustering used here is different from standard K-means clustering we used for segmentation. Distance calculation is done only with a limited region.



(a) standard *k*-means searches the entire image

(b) SLIC searches a limited region

Once each pixel has been associated to the nearest cluster center, an update process shifts the cluster centers to the mean of pixels belonging to the cluster. This step is repeated iteratively until the mean converges. After K-means has converged, SLIC eliminates any connected region whose area is less than "minRegionSize" pixels. This is done by merging regions to their neighbor regions.

Results

Figure 1- Original image

Results obtained with the original image and with,

- input “regionSize” = 10
- input “regularizer” = 0.5.

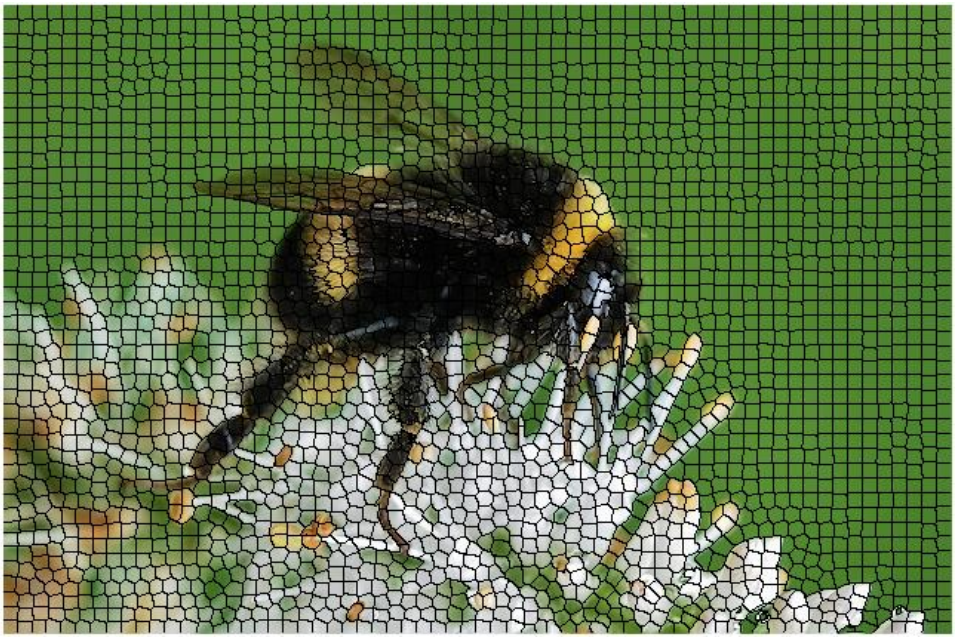


Figure 2 - Original image with super-pixel mask

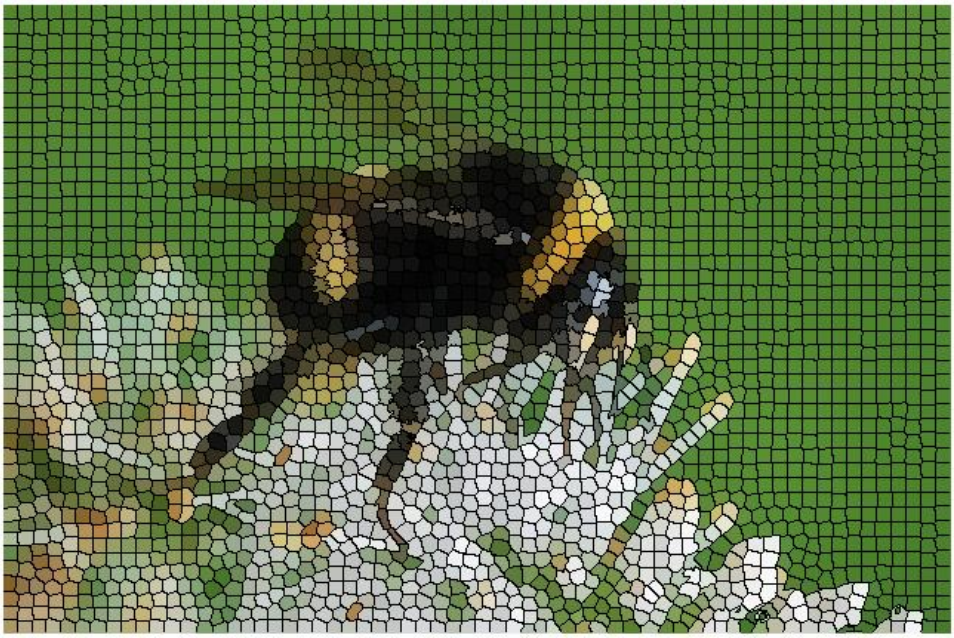


Figure 3 - SLIC super-pixel image

2. K-means clustering

For color image segmentation preferred color space is HSV. because HSV separates color information (Chroma) and image intensity or brightness level (Luma) which is very for image segmentation. So as the first step in this project, RGB images are converted into HSV color space.

Then decorrelation stretching is applied to the image. Here decorrelation stretching is used to enhance the color differences found in the image. Basic idea of this function is to replace the original color values of the image with a new set of color values with a wider range. In that case Matlab's built-in function "decorrstretch" was used.

Objective function of k-means clustering

$$SSE = \sum_{k=1}^{K} \sum_{p \in S^k} ||f_p - \mu_k||$$

This objective function is also known as sum of squared errors function and from the value of sum of squared errors we can determine whether the data points clustered tightly (SSE is small) or loosely (SSE is large).

Algorithm for k-means clustering

1. Initialization step - pick K cluster centers.
2. Assign each pixel to closest cluster center.
    - By computing Euclidian distance from each pixel to the cluster center.
3. Compute means in each color channel for each cluster.
    - Mean of K^{th} cluster:

$$\mu_k = \frac{1}{|S_k|} \sum_{p \in Sk} f_p$$

4. Shift cluster center to the computed mean value.
5. Re-assign each pixel to closest cluster center.
6. Iteratively repeat step 3 to 5 until mean converges (until clusters stop changing).

Results

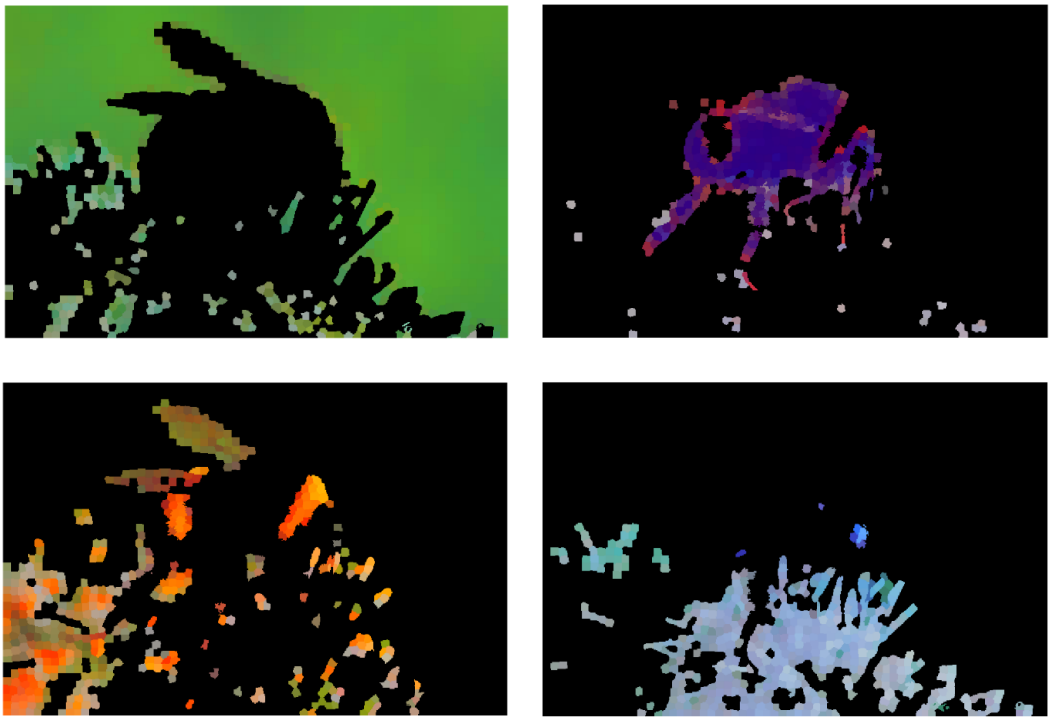


Figure 4 - Images corresponding to each cluster

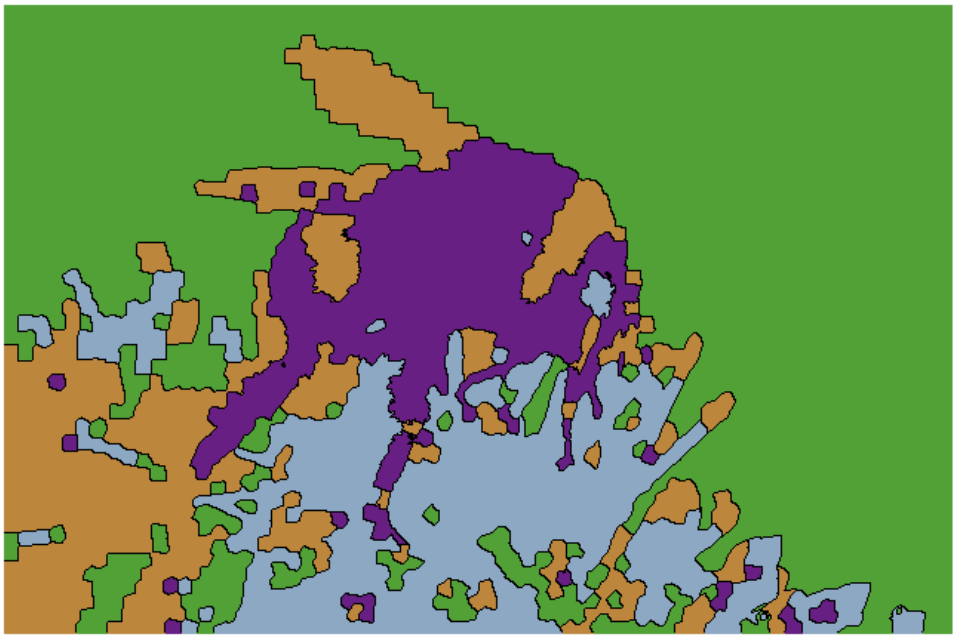


Figure 5 - Clustered super-pixel image

These set of graphs shows how H,S,V component of each cluster center changes in each iteration. Matlab algorithm run for 10 iteration but it is observed that mean get converged even before 5th iteration.

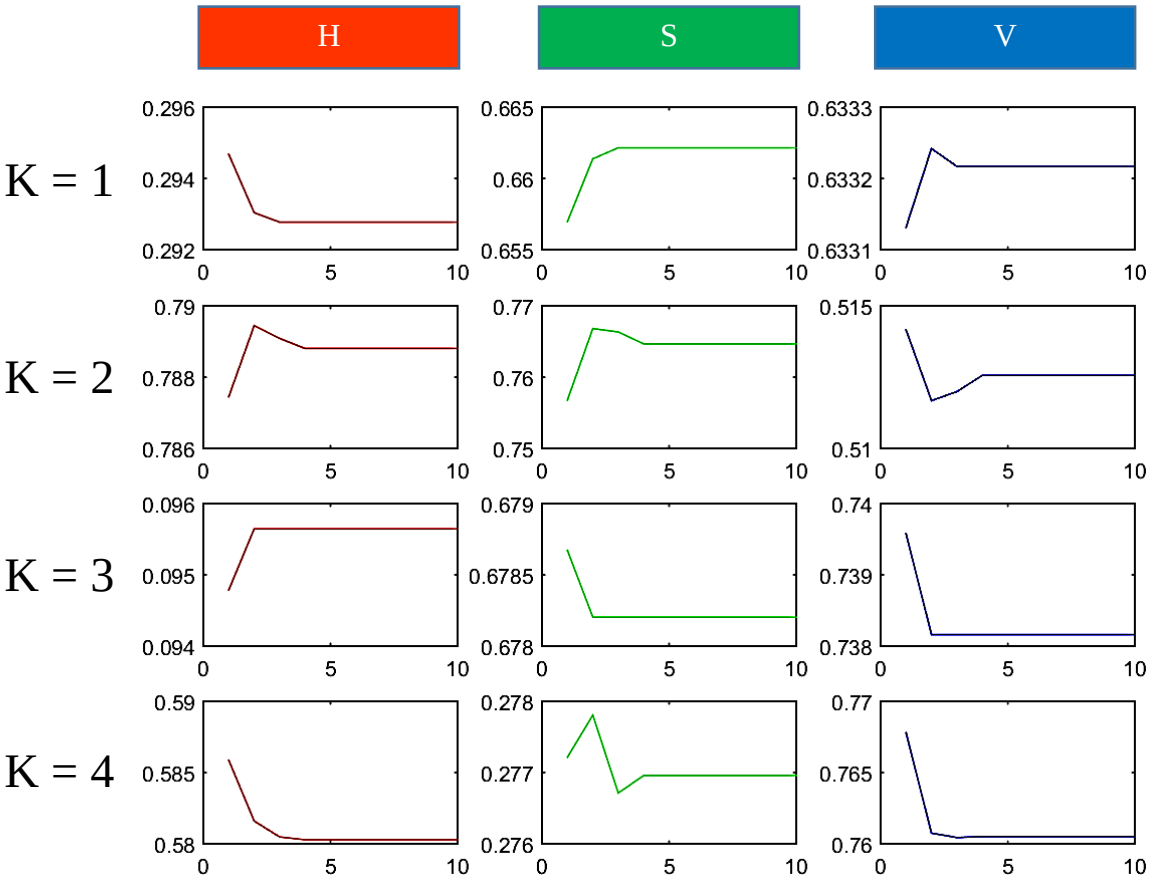


Figure 6 - Plot of mean value of each channel vs No of iterations

3. Comparison

This section shows a comparison between standard k-means clustering results and results of k-means clustering after image is divided into superpixels.

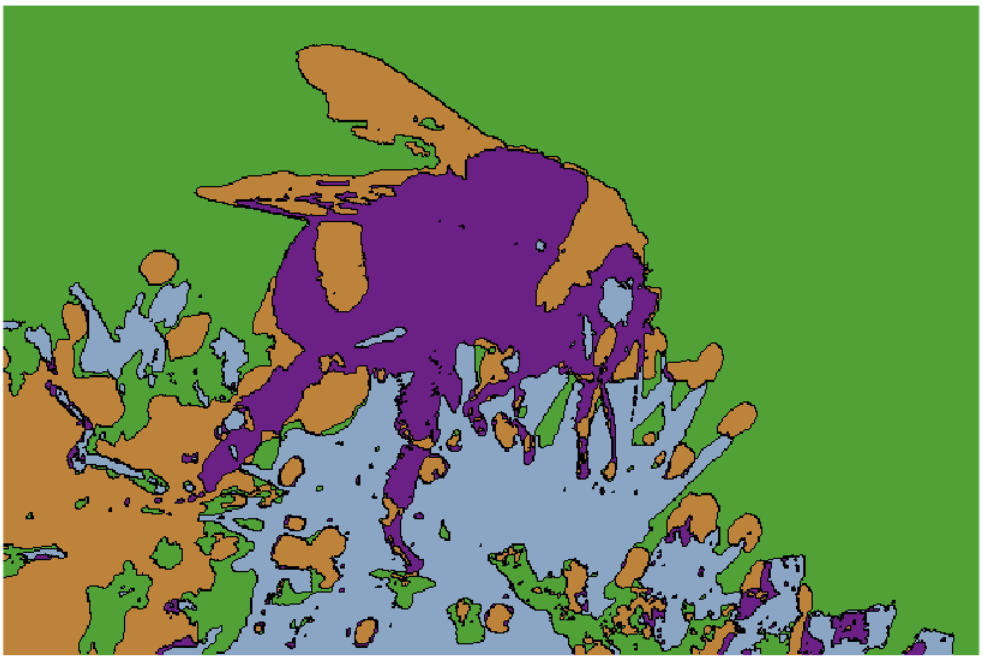


Figure 7 - Standard K-means clustering

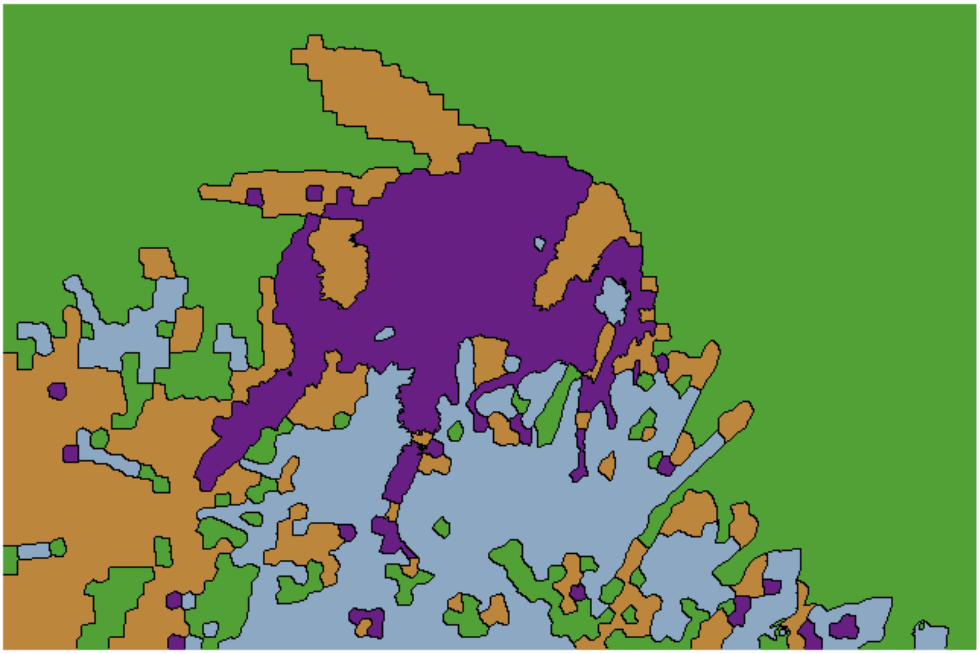


Figure 8 - Clustered super-pixel image

References

http://www.kev-smith.com/papers/SLIC_Superpixels.pdf

http://ieeexplore.ieee.org/document/6205760/

http://www.vlfeat.org/overview/slic.html

https://people.rit.edu/ndcsma/pubs/SPIE_DSS_2015_Zhang.pdf

GitHub project link

https://github.com/nisaldilshan/SLIC-superpixel-Kmeans-clustering