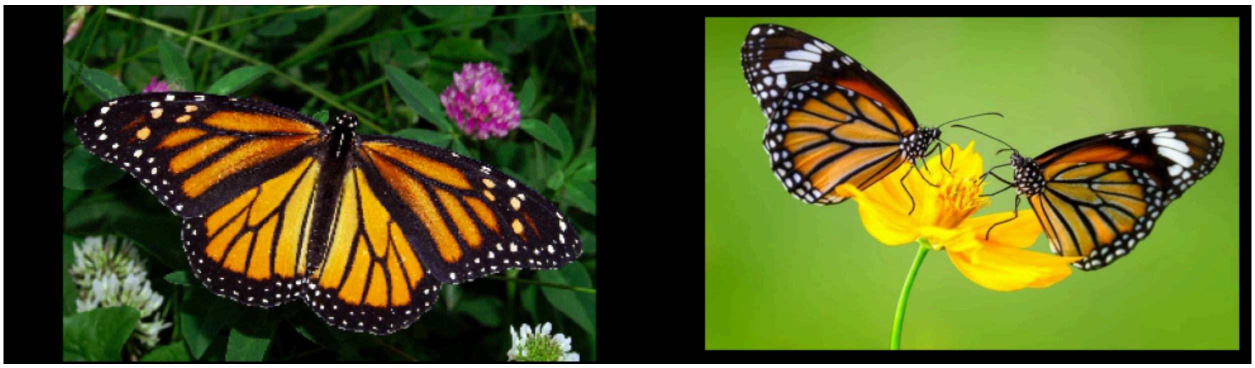
Programming Assignment - 2, Computer Vision

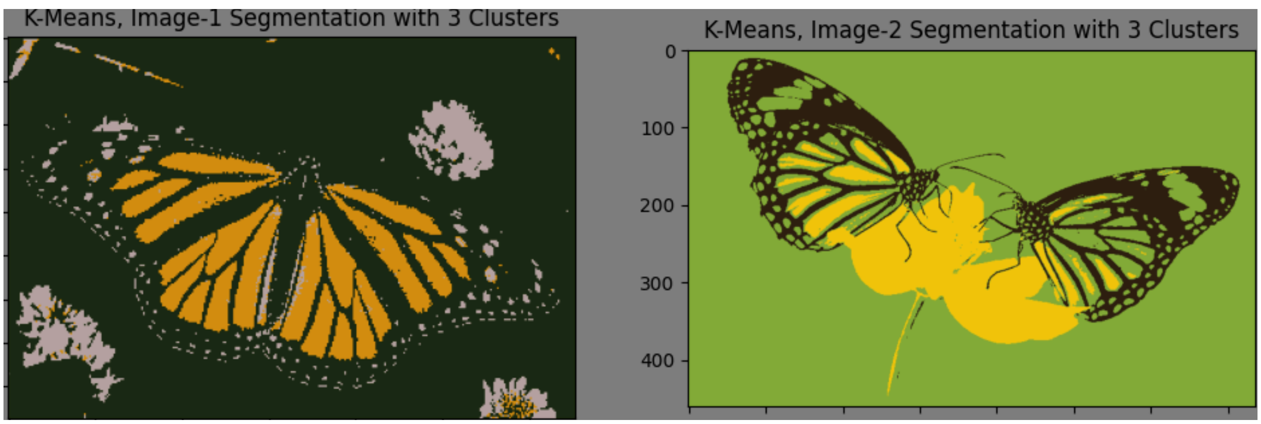
Segmentation Code Explanation

Original Image:

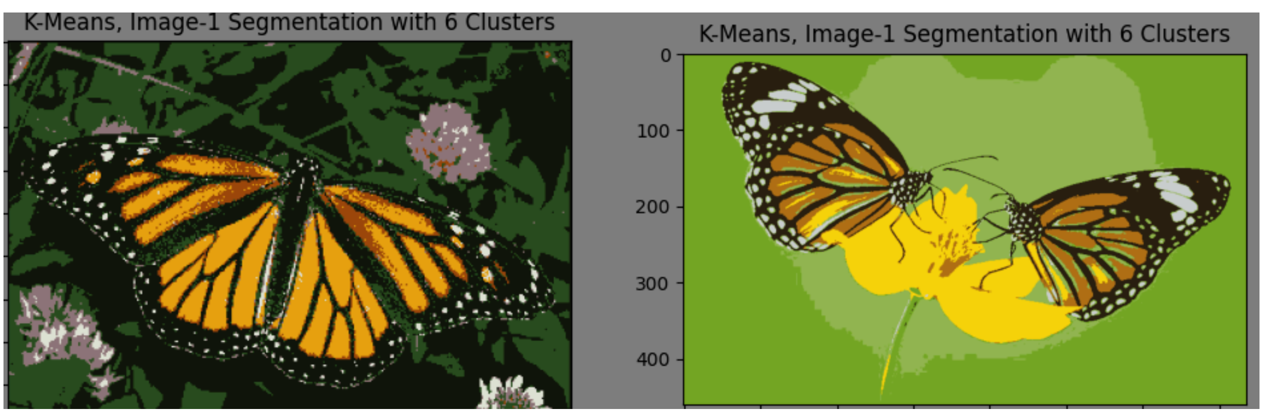


KMeans Clustering on Original Image (without Downsampling):

For K = 3

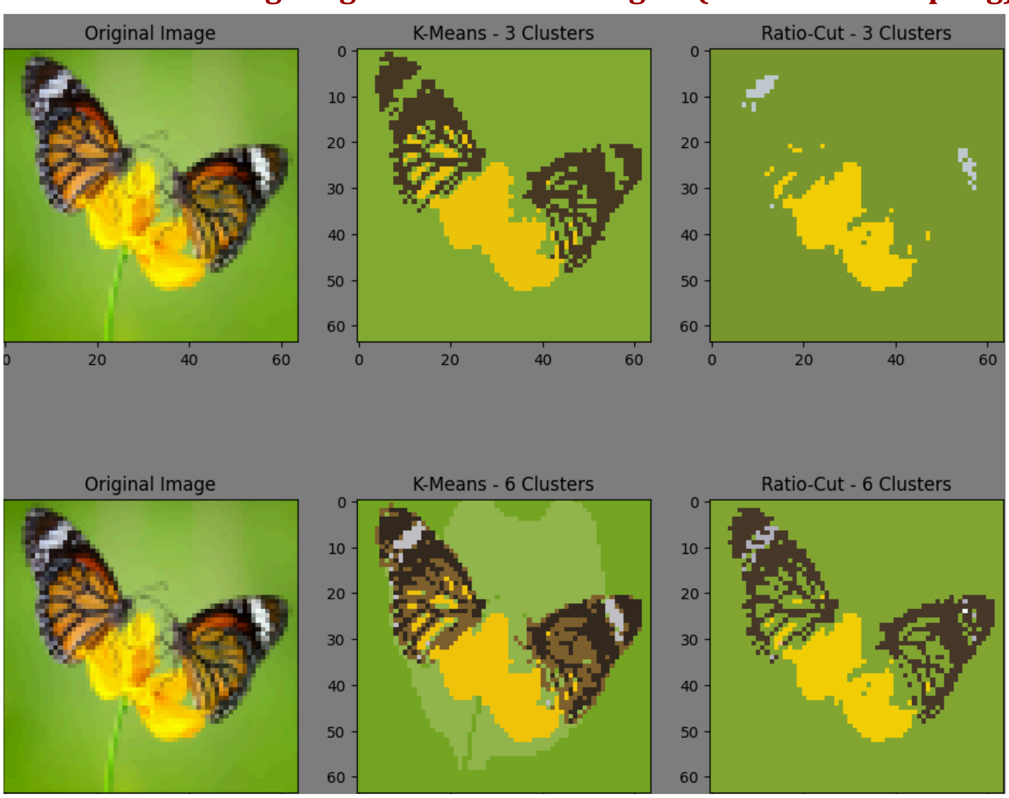


For K = 6



KMeans and Ratio Cut Image Segmentation For Image 1 (after downsampling):

KMeans and Ratio Cut Image Segmentation For Image 2 (after downsampling):



Ratio Cut & Spectral Clustering:

ratio_cut = trace(H^T L H)

To minimize the ratio cut we minimize the above expression. For this we can see in the lecture notes the derivation of optimal value of H

Problem Formulation

$$\min_{\mathcal{C}_1,\ldots,\mathcal{C}_k} \text{RatioCut}(\mathcal{C}_1,\ldots,\mathcal{C}_k) \Leftrightarrow \min_{\mathbf{H}\in\mathbb{R}^{n\times k},\mathbf{H}^\top\mathbf{H}=\mathbf{I}} \text{trace}(\mathbf{H}^\top\mathbf{L}\mathbf{H}).$$

Rayleigh quotient

$$\mathbf{v}^\star = \underset{\mathbf{v}\in\mathbb{R}^n,\mathbf{v}^\top\mathbf{v}=1}{\arg\min} \mathbf{v}^\top\mathbf{L}\mathbf{v}$$

$$\begin{aligned} f(\mathbf{v}) &= \mathbf{v}^\top\mathbf{L}\mathbf{v} + \lambda(1-\mathbf{v}^\top\mathbf{v}) \\ \nabla f &= 2\mathbf{L}\mathbf{v} - 2\lambda\mathbf{v} \\ \mathbf{L}\mathbf{v} &= \lambda\mathbf{v} \\ \mathbf{v}^\top\mathbf{L}\mathbf{v} &= \lambda. \end{aligned}$$

Therefore, we have to minimize λ such that $\mathbf{L}\mathbf{v} = \lambda\mathbf{v}$.Hence, $\mathbf{v}^\star =$ eigenvector of the matrix $\mathbf{L}$ corresponding to the smallest eigenvalue $= \mathbf{u}_1$.

Thus we'll use the eigenvectors corresponding to the minimum eigenvalues to calculate the H matrix, then using this matrix we'll do KMeans clustering to group the pixels to perform segmentation.

Comparison Analysis:

Using K Means Clustering on our Downsampled image I was able to get better results in comparison to Ratio Cut.

The reason for better performance of Ratio Cut is because the optimal hyperparameters for the same were not found and sub optimal values are used for image segmentation.

The values of hyperparameters used were obtained by tuning them with multiple values and trying different combinations.

For K=3 and K=6 we can the improvement in performance of both the algorithms as we increase the clusters this is because the colours in the image are greater than 3 which leads to better segmentation of images as the number of clusters is increased from 3 to 6.