Question 1:

1) Ncuts Code Explanations:

- First we compute the similarity matrix(**w_matrix**). That is to compute the weight between two nodes in the graph. The weight is based on both the `x_norm` and the intensity difference (**`f_norm`**) between two pixels.
- Spatial distance is set at a threshold (r) then weight is calculated using the exponential function with different parameters for spatial and intensity differences.
- Computes the diagonal degree matrix (**`d_matrix`**) based on the weight matrix. Each diagonal element represents the sum of weights for the corresponding node.
- Performs spectral clustering to segment the input grayscale image. Computes the Laplacian matrix(**w_matrix - d_matrix**) using the weight matrix and degree matrix. Calculates the generalised eigenvalues and eigenvectors of the Laplacian matrix.
- Selects the second smallest eigenvalue and its corresponding eigenvector.Thresholds the eigenvector to obtain a binary segmentation. And then displayed the segmentation

- **K-Means:** reshapes the image array into a two-dimensional array where each row represents a pixel and each column represents a colour channel (RGB). Take the value of k in range 3 to 6.
- k-Means class is imported from the scikit-learn library. fits the KMeans model to the flattened image data. It performs the clustering based on the pixel values.
- cluster labels assigned to each pixel and reshapes it to match the shape of the original image. The shape is determined by the first two dimensions of the original image, representing its height and width.

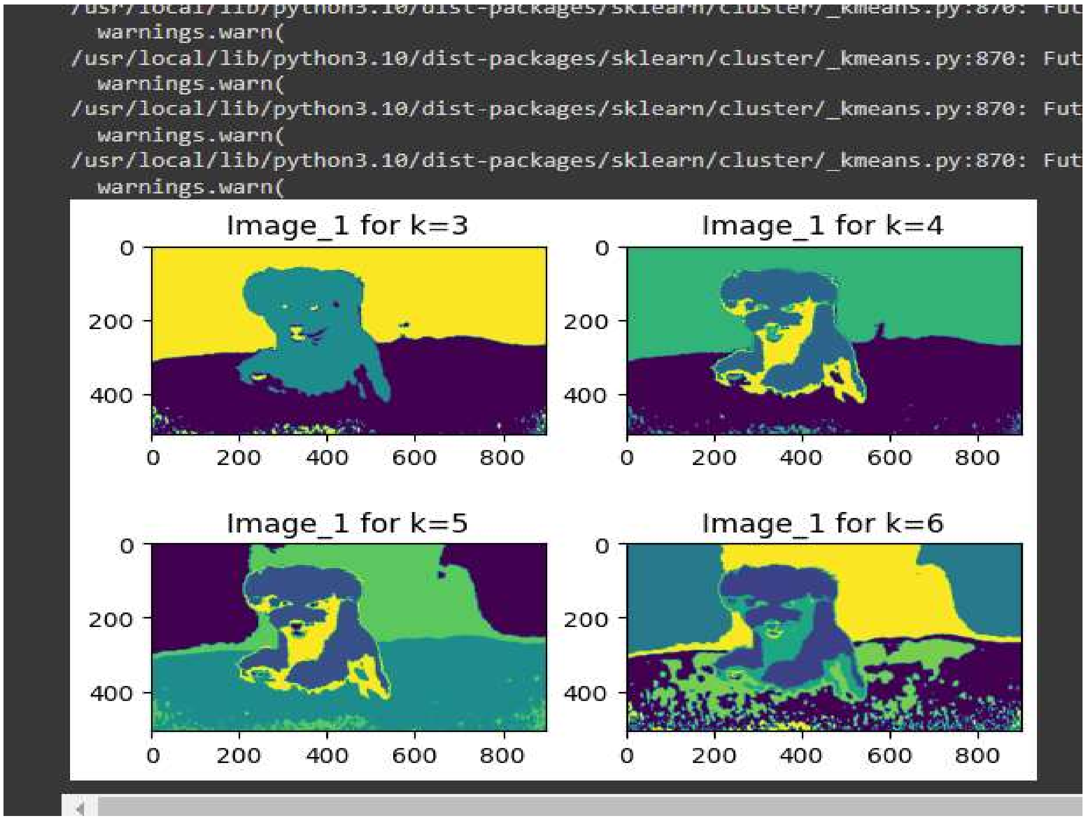
2) Qualitatively Analysis:

- The image is represented as a graph, where each pixel corresponds to a node. Edges connect neighbouring pixels, capturing their similarity. The goal is to partition the graph into segments (clusters) such that, Pixels within the same segment are similar (high intra-segment similarity). Pixels across different segments are dissimilar (low inter-segment similarity). The **normalised cut criterion** is used to achieve this balance.
- Measures both the total dissimilarity between different segments and the total similarity within each segment. Optimization involves solving a generalised eigenvalue problem. The resulting partition provides meaningful image segments.
- **Advantages of N-cut:**

  i) Handles global information, capturing the overall image structure.

  ii) Effective for both static images and motion sequences.
- **Limitations:**
  i) Computationally expensive due to eigenvalue computation.
  ii) Sensitive to initialization and parameter choices.
- **K-means** is an unsupervised clustering algorithm. Given an image, it identifies K clusters based on pixel similarity. Each cluster represents a segment.
- K-means is widely used for image segmentation. It can handle small datasets effectively. The algorithm segments objects in images based on colour similarity.
- Varying K allows us to explore different levels of granularity:
  - Smaller K results in coarse segmentation or less detailed.
  - Larger K leads to finer-grained segmentation or more detailed.

- <u>K-Means_segmented_images:</u>

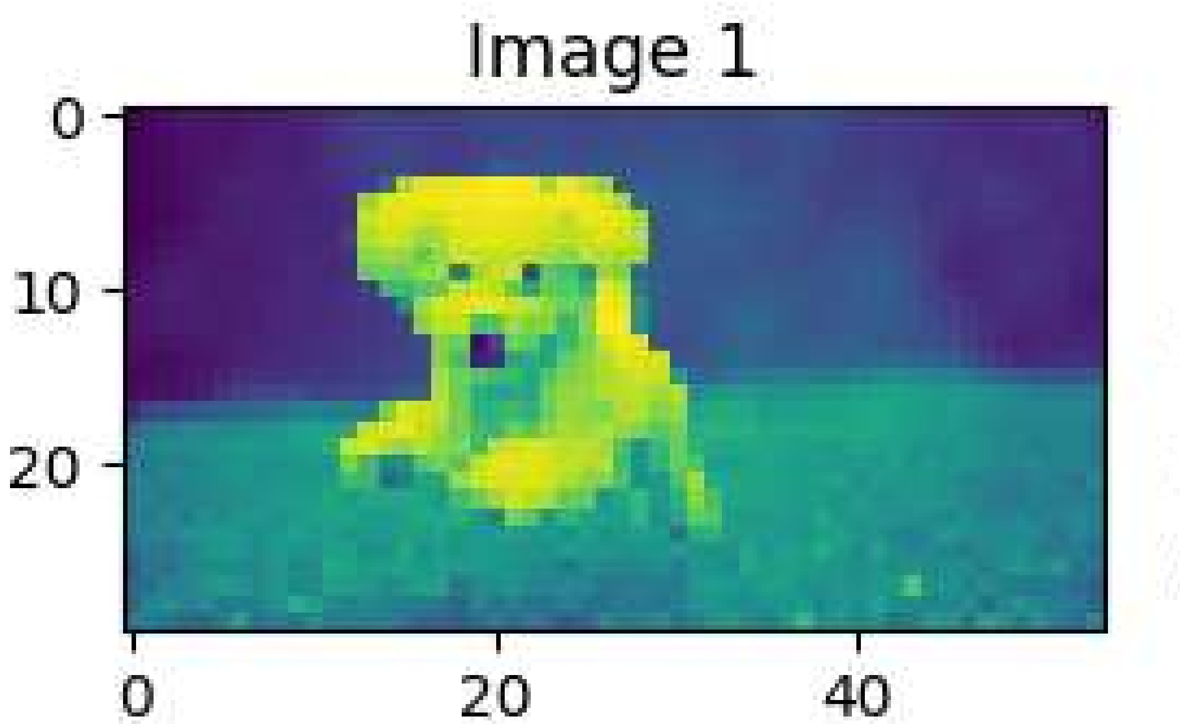


3) <u>Learnings:</u>

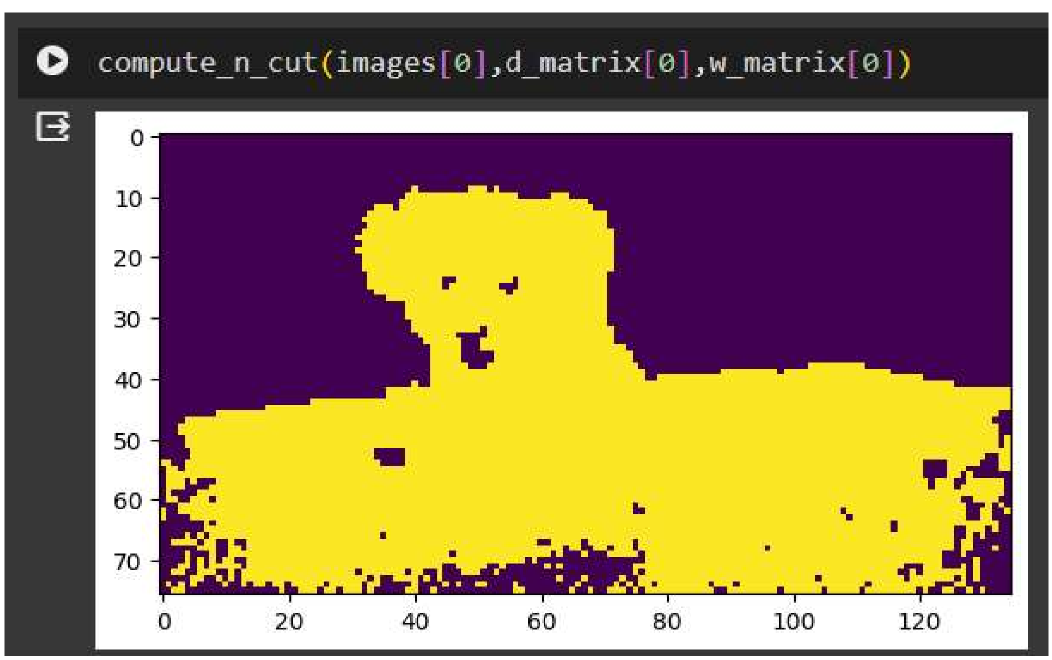
- Understanding and implementing spectral clustering for image segmentation.
- Representing images as graphs where pixels are nodes and edges represent similarities. Computing weight matrices to capture pairwise similarities and degree matrices to represent node degrees.
- Using eigenvalue decomposition to analyse the Laplacian matrix and identify clusters.Segmentation based on thresholding eigenvectors to partition images into distinct segments.

4) link of codes used, and other details:

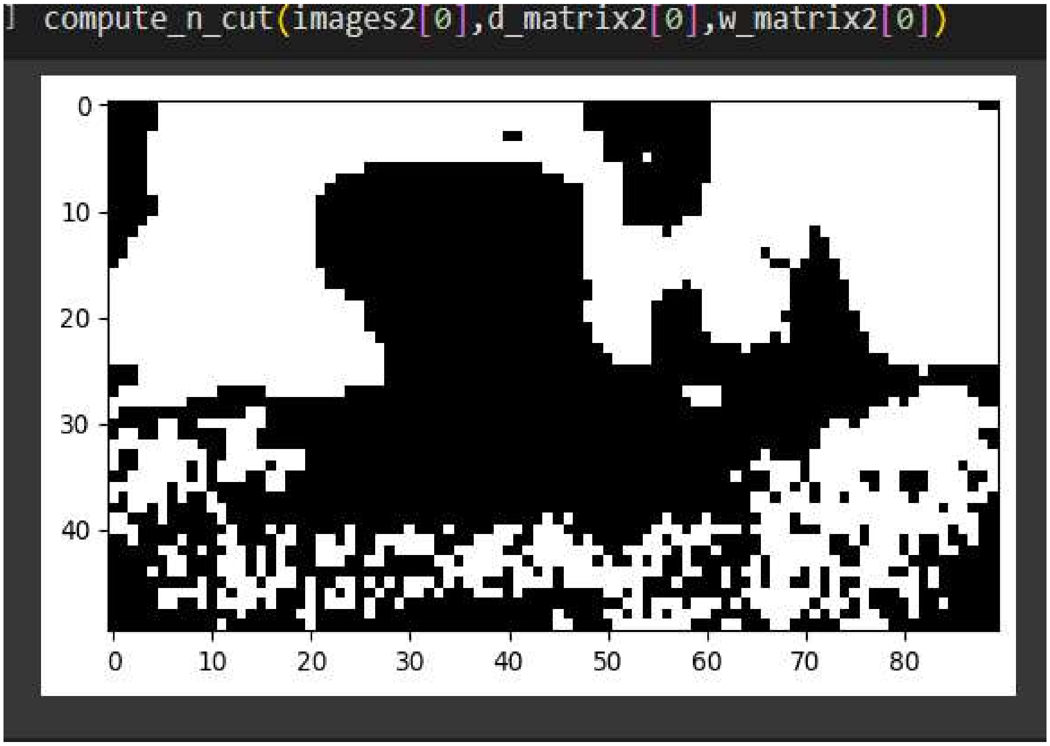
- [Colab Code Link]()
- **Images**



- One_segment_image:



- <u>Two_segments_image:</u>



- <u>Three_segments_images:</u>