IMAGE SEGMENTATION USING k-MEANS CLUSTERING

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***Abstract*—Image segmentation is the process of dividing an image into multiple segments. Meaningful segments can then be utilized for focused processing. Image segmentation is done usually based on dissimilarities or continuities of an image. This study looks to use k-means clustering algorithm as a way of segmenting images based on similarities. The similarity measure used was the Euclidean distance between the various channels of a pixel and the respective centroid values. This methodology can also be utilized as a means of achieving lossy compression of images.**

***Index Terms*— Image Segmentation, k-means, pixels, Euclidean distance, image.**

I. INTRODUCTION

Object detection has found its way into our lives and the technologies that we have been developing intricately. Image segmentation provides us with a way of object detection, that is by segmenting an image we can detect the edges of objects much more efficiently. In this project we have used a clustering algorithm called the k-mean algorithm. The k-means algorithm uses *k* centroids as cluster centers for the *k* clusters that it generates.
The k-means algorithm being an unsupervised algorithm does not require any training. It can be deployed onto given images.
The inputs that we are using are Bitmap Images (.bmp format). We are exploiting the inherent nature of such images to use the various bitmaps of channels in the image for calculating the means for every cluster based on the pixels that belong to a particular cluster.
The main objective behind this project is to develop a system that takes as an input an image and outputs a segmented image based on the number of pre-decided clusters and the Euclidean similarity measure.

II. LITERATURE REVIEW

Image Segmentation

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as image objects). The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images.
More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic chosen. Segmentation can be done based on either dissimilarities or similarities in the pixel grid of the image. On the bases of dissimilarities, point, line and edge detection can be done. On the bases of similarities, similar region detection is done to be included in the same segmented sub-section of the image. The study will look to use clustering, based on pixel intensities, as a way of clustering together pixels of similar intensities. Once these clusters are decided, the cluster center value will be assigned to each pixel in that cluster. Thus, the image is segmented and its features are more prominently visible.

k-means Clustering

k-means clustering algorithm aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster. This results in a partitioning of the data space into cells.
There are several ways of implementing k-means. The most common algorithm uses an iterative refinement technique. It is sometimes also referred to as naive k-means, because there exist much faster alternatives.
Given an initial set of k means $m_1^{(1)},\dots,m_k^{(1)}$, the algorithm proceeds by alternating between two steps:
Assignment step: Assign each observation to the cluster whose mean has the least squared Euclidean distance, this is intuitively the "nearest" mean.
Update step: Calculate the new means (centroids) of the observations in the new clusters.
The algorithm has converged when the assignments no longer change. The algorithm does not guarantee to find the optimum.

Euclidean Similarity Measure

Euclidean distance is the similarity measure that is used by the clustering algorithm. It is used to cluster together similar datapoints. In this case, the study considers the intensity values red, green and blue of a pixel to decide the clusters that are to be generated.
The Euclidean distance between points p and q is the length of the line segment connecting them.
In Cartesian coordinates, if $p = (p_1, p_2,\dots, p_n)$ and $q = (q_1, q_2,\dots, q_n)$ are two points in Euclidean n-space, then the distance (d) from p to q, or from q to p is given by the Pythagorean formula:

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1-p_1)^2+(q_2-p_2)^2+\cdots+(q_n-}$$

$$= \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}.$$

Fig 1. Euclidean Similarity Measure formula for two points in Euclidean n-space.

In case of this study, each pixel is described by three intensity values so it can be seen as lying in a Euclidean 3-space.

III. PROBLEM FORMULATION

Object detection is the need of the hour, it has become a crucial part of the technologies that we use. Image segmentation provides a much quicker way of object detection. The system finds its use cases in various fields. Be it automated driving or disease detection. The proposed system would use the k-means algorithm to map the pixels of an image to certain pre-decided number of intensity values for RGB. The pixels will be assigned the average value of R, G, B respectively based on all the pixels part of the cluster.

The input to the system is in the form of single images in the bmp format at the moment. This can be improved in the future according to application example: Batch processing in case of non-real time data. The output of the system is two side by side images, the left one being the original input image. The right image being the output image generated by the system. This image will have fewer unique intensity values decided as per the number of clusters.

IV. PROPOSED METHODOLOGY

The image input is given in .bmp format. This image has pixels with three components namely, red, green and blue intensities. A number of clusters are decided to segment the image into.

The initial choice of cluster centers is made randomly. This initial choice affects how well the image is segmented and which intensities are chosen for each of the clusters.

Owing to this, we included a block in the code that generates a set of initial random cluster centers. For each of these centers in the set, k-means algorithm is run and a cost for these centers is stored. After having gone through the entire set, that k-means clusters are chosen for those initial cluster centers that have the minimum recorded cost. This approach is followed for each input image. This helps us as we don't rely on a single random assignment anymore. We choose the best random assignment from a set of random assignments.

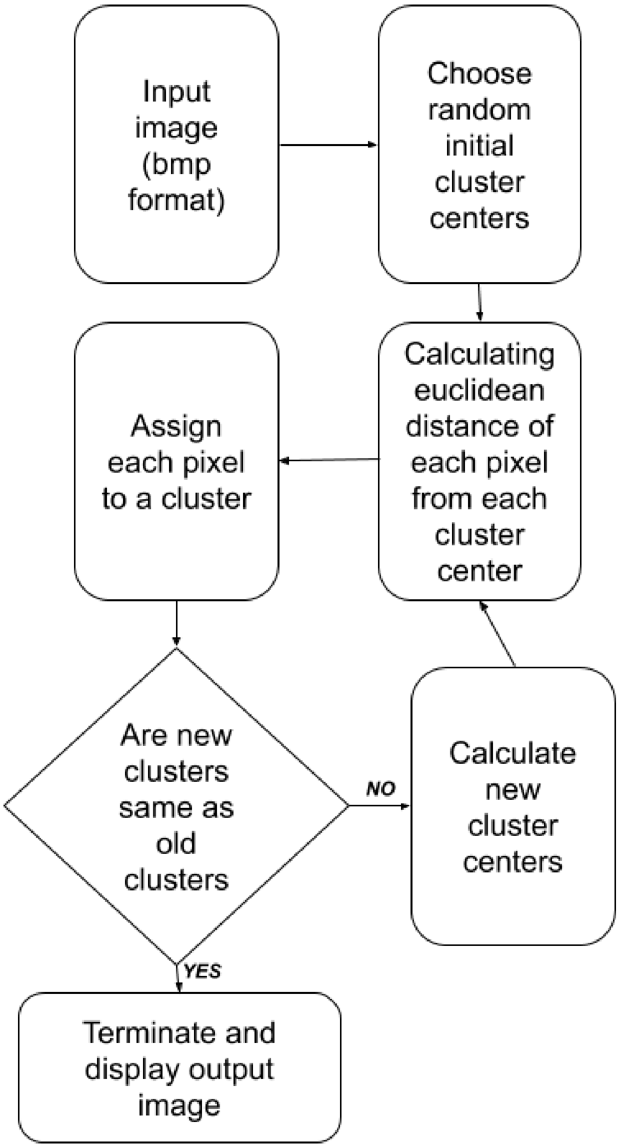

Fig 2. Flowchart for Image Segmentation Using k-means

Once the final set of clusters are formed all the pixels belonging to a particular cluster take up the RGB values of their respective cluster centroids.

V. RESULTS

The results are in line with the segmentation that was expected to be obtained. The prominent features of the image are distinctly highlighted when two clusters are chosen as in the case of Figure 3 and with ten different initial random assignments the most appropriate intensities for RGB values giving the least cost are chosen.

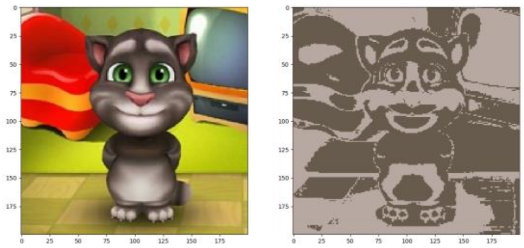

Fig 3. Image with 2 clusters with best random assignment for initial centers chosen from 10 random assignments.

As the number of clusters are increased, the image created more aptly resembles the original image as seen through Figures 4, 5 and 6. Another application of this clustering is compression. Note how the original image used in Figure 6 is a 200 x 200 pixel grid. The new image output obtained on clustering also possesses the same dimensions. However, the original image can have a maximum of 40,000 different intensity values. Whereas, the output image, having been segmented into 200 clusters, will have merely 200 unique intensity values. This technique, thus, can be used for compression of images which will be a lossy compression.

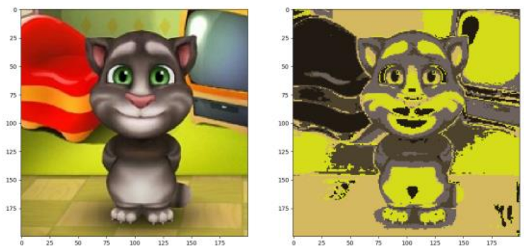

Fig 4. Image with 5 clusters with best random assignment for initial centers chosen from 10 random assignments.

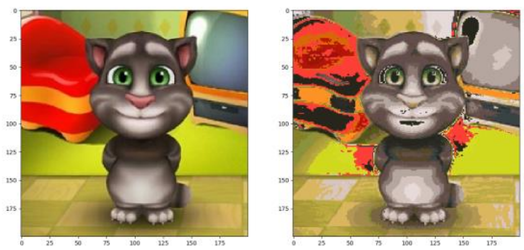

Fig 5. Image with 40 clusters with best random assignment for initial centers chosen from 10 random assignments.

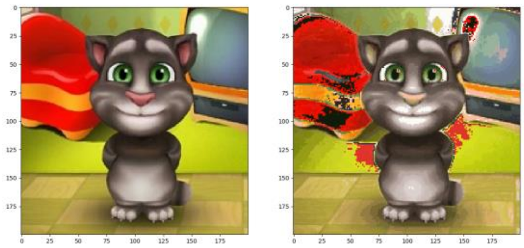

Fig 6. Image converted to image with 200 clusters

The same segmentation with 50 clusters is exhibited on another image of a scenery. Observe how in each of these examples the colour white is not always appropriately displayed on clustering. This is owing to the fact that the colour white is constituted of all the RGB intensities equally. On clustering, the colour white tends to be exhibited by all these three colours wherein one of them tends to overpower and the output image thus is rendered to have this overpowering value seen more prominently.

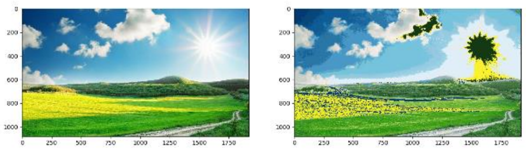

Fig 7. Scenery image converted to image with 50 clusters

VI. CONCLUSION

Image segmentation is an important step in image processing. It usually serves as the pre-processing step before pattern recognition, feature extraction, and compression of an image. The goal is to change the representation of an image into something more meaningful and understandable. This study does image segmentation by employing k-means clustering and gives output images as expected to be obtained. The program runs multiple times so as to minimize the effect that obscure initial cluster centers could have on the output image. To do this the system calculates the cost using a cost function and chooses the centers which led to minimum cost.

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