IMAGE SEGMENTATION

Project Report

EKLAVYA MENTORSHIP PROGRAMME
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MUMBAI

AUG-SEPT 2022

Acknowledgement

The Image Segmentation was a fantastic opportunity for us both to explore the Unsupervised Branch of Machine Learning And Computer Vision. From the beginning to the end of our project, we truly enjoyed every stage. We learned a tonne of technical information and were excited to discover the fresh, intriguing ideas. At every step of the way, our mentors were there to help us and share their extensive knowledge. We would like to express our sincere gratitude to SRA for providing us with this chance and experience.

Special Thanks to our Incredible Mentors

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1. Project Overview:

1.1 Description Of Use Case Of Project

Main aim of our project is to differentiate an image into K clusters which have similarity in their features.
The mechanism of our project might get application in :

- Medical field in order to detect tumor cells or foreign body cells in our body using image segmentation.
- Geological field in order to divide the terrain of an image into different features such as grass, water and all. For analysis purpose.
- Any field where data extraction is required from image as image segmentation is an important preprocess required for the task.

2. Introduction:

2.1 Brief Idea

Clustering is one of the most common exploratory data analysis technique used to get an intuition about the structure of the data. It can be defined as the task of identifying subgroups in the data such that data points in the same subgroup (cluster) are very similar while data points in different clusters are very different. Clustering (including K-means clustering) is an unsupervised learning technique used for data classification.
Out of various clustering techniques such as :

- Centroid Based Clustering
- Fuzzy Clustering
- Density Based Clustering ……….

K-Means Clustering is the most common, best and highly used method for clustering data.

2.1 Basic Project Domains

- Image Processing
- Machine Learning
- Clustering

Link to our [Github Repo]

3. Stages Of Project:

The entire process of Unsupervised Image Segmentation can be divided into 3 steps for better understanding purposes. These steps are :

- Initialization
- Clustering
- Processing

3.1 Initialization

Initialization is an important step in the Image Segmentation process. Initialization is used to decide initial cluster centroids for implementing K-Means. As we all know, initial cluster centroid selection plays an important role in improving efficiency as well as accuracy of clustering data. Getting more accurate cluster centroid results helps in faster execution of K-Means algorithm with highly accurate outputs. We have performed 3 methods to implement Initialization are :

3.1.1 Subtractive Clustering

Subtractive clustering method is data clustering method where it generates the centroid based on the potential value of the data points. So subtractive clustering is used to generate the initial centers and these centers are used in the k-means algorithm for the segmentation of image. It distributes the data space into grid points and computes the potential for each data point based on its distance to the actual data point. So the grid point with many data points nearby will have high potential value. And so this grid point with highest potential value will be chosen as the first cluster center. So after selecting the first cluster center we will try to find the second cluster center by calculating the highest potential value in the remaining grid points. As grid points near the first cluster center will reduce its potential value, the next cluster center will be grid with many data points nearby other than the first cluster center grid point. So this procedure of acquiring a new cluster center and reducing the potential of surrounding grid points repeats until the potential of all grid points falls below a threshold value.

3.1.2 K-Means++

This algorithm ensures a smarter initialization of the centroids and improves the quality of the clustering. Apart from initialization, the rest of the algorithm is the same as the standard K-means algorithm. That is, K-means++ is the standard K-means algorithm coupled with a smarter initialization of the centroids.

3.1.3 Random Initialization

In this method, we basically iterate for a certain time to find random clusters. And in this iteration, data points which are far away from one another are chosen to be our initial cluster centroid for K-Means. We do this because we want to segment image very accurately and if clusters are far away from one another,it will give us better output.
In this method randomly 10 sets of K cluster centroids are created. We calculate the sum of squares of distances between cluster centroid for each set. The set with the largest sum is chosen as it consists of centroids which are far away from each other.

3.2 Clustering

Clustering can be defined as the task of identifying subgroups in the data such that data points in the same subgroup are very similar while data points in different clusters are very different. 2 methods to implement Clustering are:

3.2.1 K-Means

K-Means algorithm is an iterative algorithm that tries to partition the dataset into K pre-defined distinct non-overlapping subgroups (clusters) where each data point belongs to only one group. It tries to make the intra-cluster data points as similar as possible while also keeping the clusters as different (far) as possible. It assigns data points to a cluster such that the sum of the squared distance between the data points and the cluster's centroid (arithmetic mean of all the data points that belong to that cluster) is at the minimum. The less variation we have within clusters, the more similar the data points are within the same cluster.

3.2.2 Improved K-Means

The main idea of algorithm is to set two simple data structures to retain the labels of cluster and the distance of all the data objects to the nearest cluster during the each iteration, that can be used in next iteration, we calculate the distance between the current data object and the new cluster center, if the computed distance is smaller than or equal to the distance to the old center, the data object stays in it's cluster that was assigned to in previous iteration. Therefore, there is no need to calculate the distance from this data object to the other k-1 clustering centers, saving the calculative time to the k-1 cluster centers. Otherwise, we must calculate the distance from the current data object to all k cluster centers, and find the nearest cluster center and assign this point to the nearest cluster center. And then we separately record the label of the nearest cluster center and the distance to its center. Because in each iteration some data points still remain in the original cluster, it means that some parts of the data points will not be calculated, saving a total time of calculating the distance, thereby enhancing the efficiency of the algorithm.

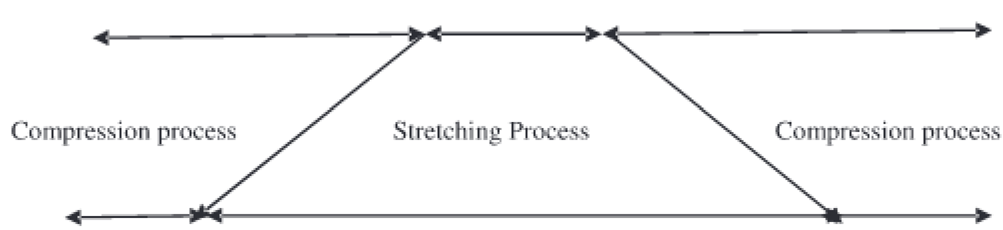
3.3 Processing

Some images used for the clustering can be of low quality or even blurred. To improve its quality , some type of processing has to be done on it to get the better output.So , we chose to use PCS i.e. Partial Contrast Stretching technique for this purpose.

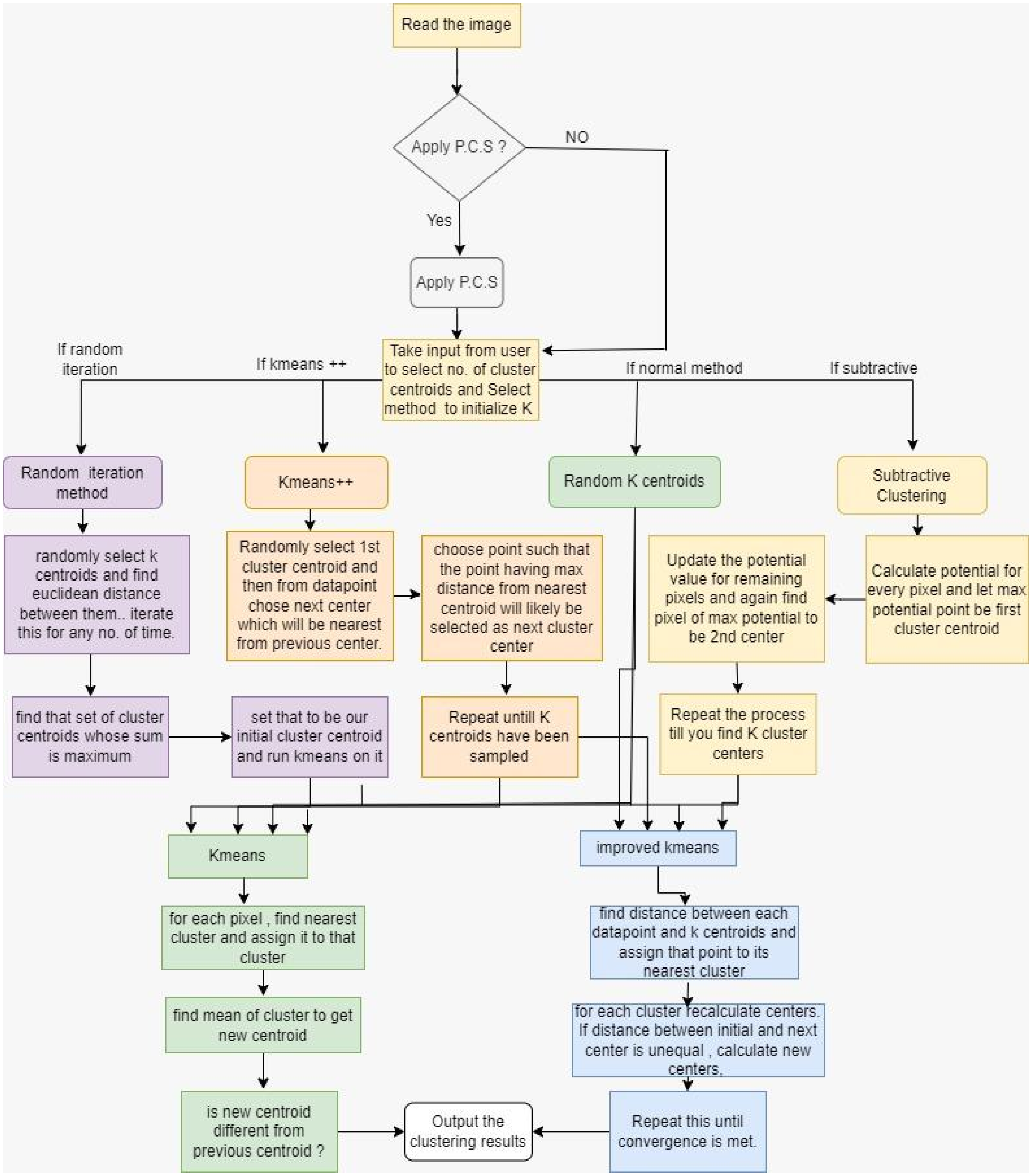
3.3.1 PCS

Partial Spatial Starching (PCS) is used to improve the image quality and contrast of the image. It is done by stretching and compression. By applying this technique, the pixel range of lower threshold value and upper threshold value will be mapped to a new pixel range and stretched linearly to a wide range of pixels within new lower stretching value, and the remaining pixels will experience compression.

For greater understanding , refer to the diagram :

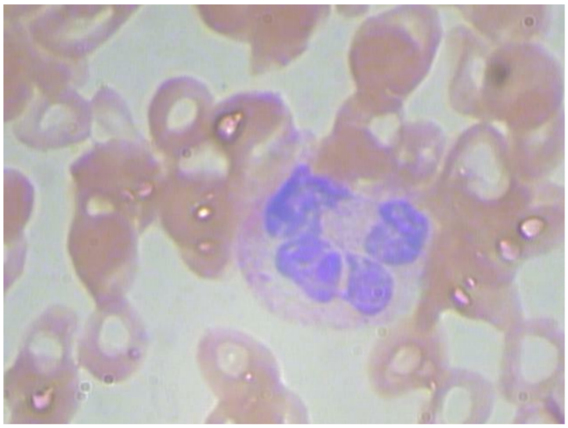


Work-Flow

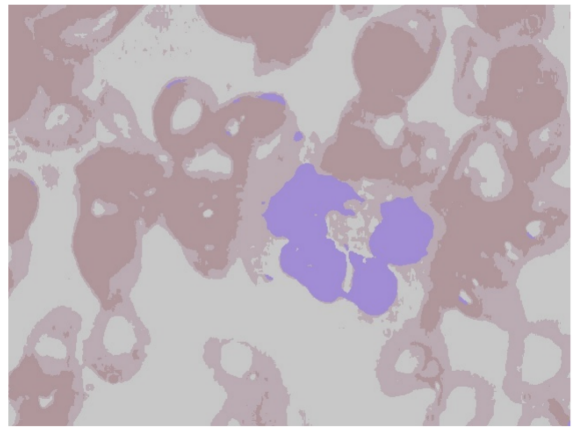

Read the image
Apply P.C.S ?
NO
Yes
Apply P.C.S
Take input from user to select no. of cluster centroids and Select method to initialize K
If random iteration
If kmeans ++
If normal method
If subtractive
Random iteration method
Kmeans++
Random K centroids
Subtractive Clustering
randomly select k centroids and find euclidean distance between them.. iterate this for any no. of time.
Randomly select 1st cluster centroid and then from datapoint chose next center which will be nearest from previous center.
choose point such that the point having max distance from nearest centroid will likely be selected as next cluster center
Update the potential value for remaining pixels and again find pixel of max potential to be 2nd center
Calculate potential for every pixel and let max potential point be first cluster centroid
find that set of cluster centroids whose sum is maximum
set that to be our initial cluster centroid and run kmeans on it
Repeat untill K centroids have been sampled
Repeat the process till you find K cluster centers
Kmeans
improved kmeans
for each pixel , find nearest cluster and assign it to that cluster
find distance between each datapoint and k centroids and assign that point to its nearest cluster
find mean of cluster to get new centroid
for each cluster recalculate centers. If distance between initial and next center is unequal , calculate new centers.
is new centroid different from previous centroid ?
Output the clustering results
Repeat this until convergence is met.

4. Conclusion And Future Work

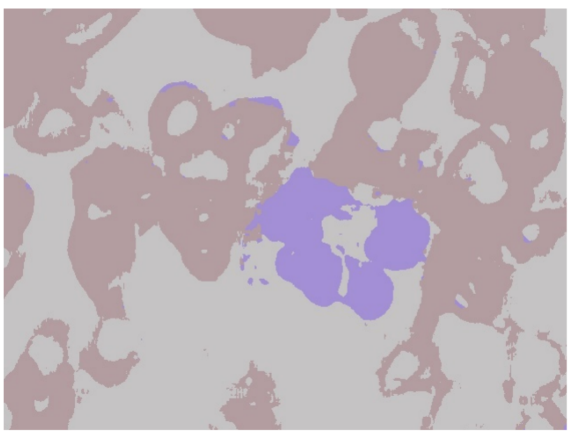
4.1 Current Efficiency And Accuracy



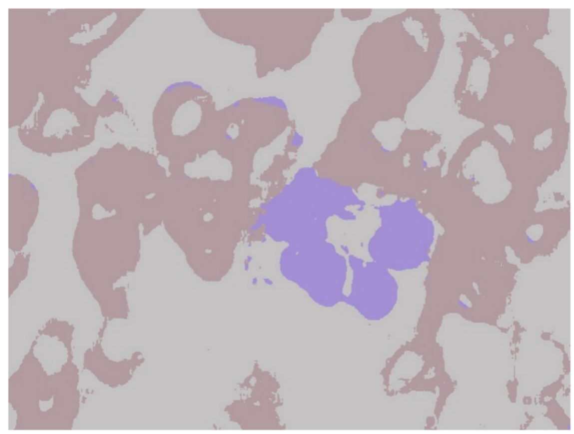
Original Image



OpenCV Output



K-Means Output



Improved K-Means output

As we can see our generated output is highly equivalent to OpenCV generated output , hence justifying high accuracy of our code. We have performed clustering on blood samples to check for presence of any foreign body, which is one of the applications of image segmentation.

4.2 Achievements Till Now

- We learnt basics of openCV and implemented it for reading images
- We created various modules to perform initialization and clustering code without using any prebuilt python libraries.
- Integrated all above codes to allow the user to choose his/her method of clustering and initialization.

4.3 Future Aspects

- To improve time complexity of code by implement Fast Based K-Means approach (FBK-Means)
- To perform semantic segmentation which helps in classifying objects present in image and help in object based extraction in images. [Link]

5. References

- https://www.youtube.com/watch?v=jAA2g9ItoAc&list=PLLssT5z_DsK-h9vYZkQkYNWcItqhlRJLN&index=3) Lec 13.1 to Lec 13.5
- https://www.kdnuggets.com/2019/05/guide-k-means-clustering-algorithm.html
- https://www.naftaliharris.com/blog/visualizing-k-means-clustering/
- https://towardsdatascience.com/k-means-clustering-algorithm-applications-evaluation-methods-and-drawbacks-aa03e644b48a
- https://medium.com/analytics-vidhya/comparison-of-initialization-strategies-for-k-means-d5ddd8b0350e
- https://www.sciencedirect.com/science/article/pii/S1877050915014143#:~:text=Subtractive%20clustering%20method%20is%20data,for%20the%20segmentation%20of%20image.
- https://ieeexplore.ieee.org/document/5453745