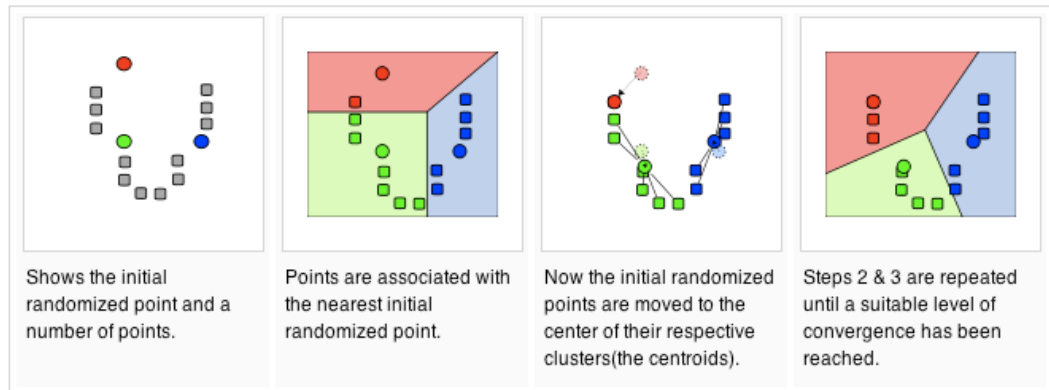# Image segmentation using K-means

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K-means clustering algorithm was developed by J. MacQueen (1967) and then by J. A. Hartigan and M. A. Wong around 1975. Simply speaking K-means clustering is an algorithm to classify or to group the objects based on attributes/features into K groups. K is a positive integer number. The grouping is done by minimizing the distances between data and the corresponding cluster centroid. The distance that will be used here is the L^2 distance $(d(\mathbf{x}, \mathbf{y}) = \sum_i (x_i - y_i)^2)$.

The aim of clustering analysis is to group data in such a way that similar objects are in one cluster and objects of different clusters are dissimilar. The K-means algorithm basically consists of three steps:

1. Initialization: K chosen, an initial set of K so-called centroids, i.e. virtual points in the data space is randomly created,

2. every point of the data set is assigned to its nearest centroid and

3. the position of the centroid is updated by the means of the data points assigned to that cluster. In other words, the centroid is moved toward the center of its assigned points.

Steps 2 and 3 are performed until no centroid was shifted in one iteration. In practice, the algorithm is stopped when the minimum shift is below a threshold. The following images demonstrate the k-means clustering algorithm in action, for the two-dimensional case.


| Shows the initial randomized point and a number of points. | Points are associated with the nearest initial randomized point. | Now the initial randomized points are moved to the center of their respective clusters(the centroids). | Steps 2 & 3 are repeated until a suitable level of convergence has been reached. |

The k-means algorithm will then find the K groups of data that minimize the following objective fonction:

$$F = \sum_{i=1}^{K} \sum_{x_j \in S_i} (x_j - c_i)^t (x_j - c_i),$$

where there are K clusters S_i, $i = 1, 2, \ldots, K$, and c_i is the centroid or mean point of all the points $x_j \in S_i$.

The k-means clustering algorithm is commonly used in computer vision as a form of image segmentation.

To each pixel of an image is associated its color described in RGB. The image to be segmented can then be represented as a set of points in a 3D data space, as illustrated in the following figure. In case of a grey-level image, the procedure is the same apart from the fact that the image is represented as a set of points in a 1D space.
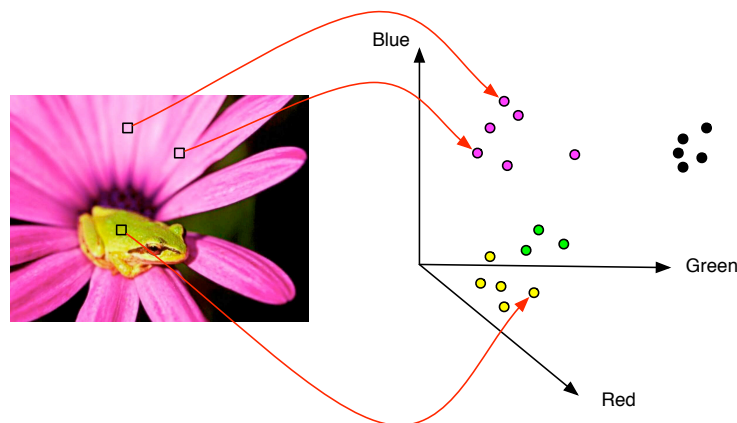
Implementation

1. Implement the K-means method to segment the grey-level images.

2. Test on few images. Illustrate your results by showing the segmented images where the regions are displayed in different grey values.

3. Extent your algorithm to color images and test on few exemples.

4. Do initial centroid positions have an influence on the result ?

5. How does the choice of K influence the result ?

6. How does the choice of the stopping threshold influence the result ?

7. To improve the result, we propose to take into account the color of each pixel and its position. The color image is then represented in a 5D space (R,G,B, line, colomn). Implement and test the K-means method to segment the images with this new representation.