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Analysis of Color Image Segmentation by K-means Clustering

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Abstract: Image segmentation is a crucial step in image processing. The purpose of image segmentation is to divide the image into objects and extract the useful information. The level of segmentation is application dependent. Color image enhances the process of feature extraction and matching as compared to grey level image. There are various techniques of segmentation of color images but the method of clustering by K-means algorithm is discussed in this paper. K-means clustering is the simplest method of clustering the objects. The number of clusters to be partitioned and a distance metric to quantify how close two objects should be to each other must be specified in the algorithm itself. The paper shows the various results of k-means clustering based on objects as well as colors by using the MATLAB software.

Keywords: Segmentation, K-means, image processing, Clustering, Pixels, Information, MATLAB.

I. INTRODUCTION

Image segmentation is a process of dividing the image into its constitute parts. The main aim of partitioning is to further analyse each of these constitutes once they are identified. Segmentation helps in extracting the information from the image and then uses this information for high-level applications. Sub-division of image should stop when the required information is extracted i.e. it is application dependent. Image segmentation techniques can be classified based on the features of image such as pixel, contour, region, model, color and can be combination of one or more features [4].

Color segmentation of an image is an important task in image analysis, image interpretation, and pattern recognition. The applications of color segmentation is in scientific and industrial fields such as medicine, remote sensing, microscopy, content based image and video retrieval, document analysis, industrial automation and quality control, etc [13]. An advantage resulting of color image representation is to enhance the performance of processes such as segmentation and feature extraction and matching because of the three fold increase in color signal dimension as compared to black and white images.

The process in which objects or pixels in an image is replaced by cluster, pixels that belong together because of same color, texture, etc is known as clustering based method [12]. Segmentation evaluation techniques can be categorised as supervised and unsupervised. Clustering is an unsupervised technique where an image is partitioned into different groups known as clusters by keeping in mind two properties: (1) High Cohesion and (2) Low Coupling. High cohesion indicates the data items belong to one particular cluster which must high similarities. Low coupling indicates that data items of one cluster should be different from the data items of the other clusters [2]. Clustering was one of the first techniques used for image segmentation based on color due to its simplicity and efficiency. After the selection and extraction of image features, the samples are grouped together in compact but separated from each other corresponding to each class of the image, that is, it is based on similarity and discontinuity. This method is known as k-means clustering [1].

K-means clustering treats each object as having a location in space. It finds partitions such that objects within each cluster are as close to each other as possible and as far away from the objects in other clusters as possible. The number of clusters to be partitioned and a distance metric to quantify how close two objects are to each other should be specified. Image segmentation is an important and difficult task for the analysis and processing of an image. Image should be segmented to our desired level to extract useful information from the image. Various fields such as image compression, image retrieval, object detection, image enhancement, etc require image segmentation [5].

II. RELATED WORK

Clustering is a process of classifying or segmenting the objects in an image. The samples of classified objects contain the similar content to one another than samples belonging to different clusters. The hard clustering scheme called k-means clustering algorithm is proposed by MacQueen in 1967 [1]. The k-means clustering method classifies each object of the data set just to one cluster. It was further modified by J. A. Hartigan and M. A. Wong in 1975 [2].

The method of implementation of Lloyd's k-means clustering algorithm is simple and efficient. This algorithm is easy to implement as it requires a k-tree as the only major data structure present in an efficient k-means clustering algorithm [4]. Then the concept based on K-means algorithm in HSI space was given [5] which have the advantage over those based on the RGB space. Both the hue and the intensity components are fully utilized. In

the process of hue clustering, the special cyclic property of the hue component is taken into consideration.

A new approach for image segmentation by applying k-means algorithm was presented [8]. In image segmentation, clustering algorithms are very popular as they are intuitive and are also easy to implement.

The concept of Image Segmentation by K-Means and EM Algorithms was described [7]. In this method, two algorithms for image segmentation are studied. K-means and an Expectation Maximization algorithm are each considered for their speed, complexity, and utility.

An overall search on the topic of clustering based image segmentation and novel approaches to FCM algorithm was given [13]. This paper described two techniques namely K-means clustering and fuzzy c-means (FCM) clustering for better segmentation results.

The use of image segmentation in lesion segmentation needed for monitoring and quantifying lesion was presented [12]. It also illustrated the k-means clustering method as an iterative technique that is used to partition an image into clusters in which there is choice of k clusters along with the types of clustering that is hierarchical clustering and partitioned clustering.

The analysis of images using cluster based segmentation techniques was done [14]. It discussed the various segmentation techniques like thresholding, edge-based detection, region based detection and clustering. The main illustration is based on the image segmentation using k-means, fuzzy c-means and clustering and corresponding results have been compared.

A survey on different techniques of data clustering was done [15]. It implemented different data clustering techniques such as k-means clustering, Fuzzy c-means clustering, mountain clustering and subtractive clustering. It analyzed these different techniques and found that k-means and Fuzzy c-means are preferred when the number of cluster is known.

A new and modified method for conventional k-means algorithm was proposed [16]. In conventional k-means algorithm, usually cluster centres are randomly initialized. But here minimum and maximum data points are used in the given data set to initialize the cluster centres. Then comparison is done between the standard and proposed k-means algorithm and was found that the proposed algorithm have effective and more robust results than the traditional k-means algorithm.

III. K-MEANS CLUSTERING ALGORITHM

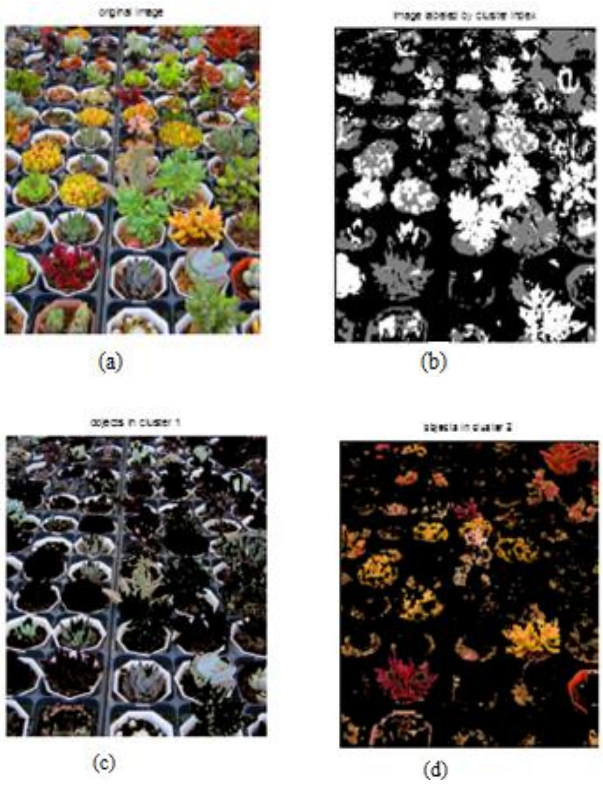
There are many methods of clustering developed for a wide variety of applications. Clustering algorithms use the unsupervised technique and find applications in various fields. K-means clustering algorithm was developed by J. MacQueen (1967) [1] and then by J. A. Hartigan and M. A. Wong around 1975 [2]. K-means clustering is a simple algorithm used 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 objects and the corresponding cluster centre. 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 [15]. Each pixel in the image is assigned to the cluster whose mean vector is closest. K-means approach is iterative and computationally intensive. Hence it is applied to image sub-areas rather than full image. The K-means algorithm basically consists of the following steps:

Step 1: Read image
Step 2: Convert the original RGB image to L*a*b color space
Step 3: Classify each pixel using K-means clustering
Step 4: Label every pixel in the image using the results from K-means clustering
Step 5: Display the images that segment the original image by Colors.

This algorithm minimizes the total distance of data points to the cluster centre, of the cluster they are assigned to [16]. Also it does not require the actual computation of distances. A drawback of k-means algorithm is that the number of desired clusters needs to be specified before.

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

K-means clustering algorithm is implemented in Matlab software and the image is segmented into clusters based on the objects in the image and the various colors in the image. In Fig 1, the image is loaded and converted into L*a*b color space. Then K-means clustering algorithm is applied and image is segmented into clusters based on the objects present in the original image. Fig 1(a) shows the original image and Fig 1(b) shows the image labelled by cluster index. Fig 1 (c), (d) and (e) shows the similar objects in different clusters. Thus the results are obtained from K-means clustering algorithm.



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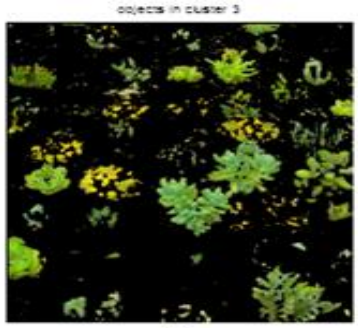

(e)

Fig 1. (a) is the original image, (b) indicates cluster index, (c-e) objects in different clusters

In Fig 2, the image is segmented on the basis of different colors present in the original image. The original image, Fig 2(a) is loaded and then K-means clustering algorithm is applied on it in MATLAB. The results obtained are the clusters formed on the basis of colors, i.e., Fig 2(b) shows the red objects present in the original image. Similarly, Fig 2 (c) shows the green color objects, Fig 2(d) shows the magenta color in the image, Fig 2(e) indicates the areas of blue color whereas Fig 2(f) has segmented the yellow color in the original image.

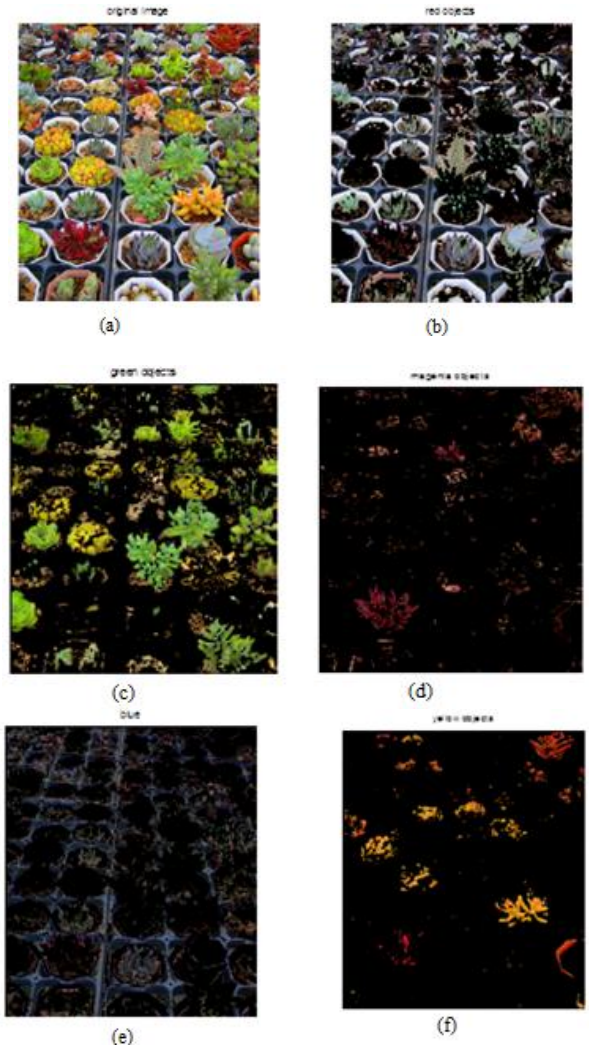

Fig 2. (a) is the original image, (b-f) indicates the objects in different clusters based on colors

Thus K-means clustering algorithm is implemented successfully for the color images. The segmentation is done on the basis of objects in the original image in Fig 1 and on the basis of colors in Fig 2.

V. CONCLUSION

Image segmentation of color image by K-means clustering technique is studied in this paper. The results are obtained by using image processing toolbox in MATLAB. The clustering is done on the basis of objects in Fig 1 and Fig 2 shows the clustering based upon different colors present in the original image. Color based segmentation is very important in image processing and finds applications in various fields such as image compression, image retrieval, object detection, image enhancement, etc.

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