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Colour Image Segmentation Using K-Means, Fuzzy C-Means and Density Based Clustering

Preeti1, Assistant Professor Kompal Ahuja2

1,2 DCRUST, Murthal, Haryana (INDIA)

DITM, Gannaur, Haryana (INDIA)

Abstract: ***Image is information which has to be processed effectively. Segmentation, partitions the image into multiple segments. Image segmentation assigns label to every pixel in an image such that pixels with the same label share certain visual characteristic. Clustering is one of the methods used for segmentation. The objective of this paper is to compare the performance of various segmentation techniques for colour images. K-Means, Fuzzy C-Means and Density Based clustering techniques are compared for their performance in segmentation of colour images.***

Keywords: Segmentation, Clustering, K-Means clustering, Fuzzy C-Means Clustering (FCM), image processing, clustering,

I. INTRODUCTION

Image segmentation is the process of partitioning a digital image into multiple segments. Each segment will represent some kind of information to user in the form of colour, intensity, or texture. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze [1]. 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 visual 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 is similar with respect to some characteristic or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s).

The importance of image segmentation can't be neglected because it is used in almost every field of science, [i.e., removing noise from an image, satellite imaging, machine vision, computer vision. It is observed that there is not a perfect method for image segmentation, since each image has its own different type. It is also a very difficult task to find a segmentation technique for a particular type of image. Since a method applied to one image may not remain successful to other type of images.

II. COLOUR IMAGE SEGMENTATION USING K-MEANS CLUSTERING

The K-Means clustering technique [6] is a well-known approach that has been applied to solve low-level image segmentation tasks. This clustering algorithm is convergent and its aim is to optimize the partitioning decisions based on a user-defined initial set of clusters.

The selection of initial cluster centres is very important since this prevents the clustering algorithm to converge to local minima, hence producing erroneous decisions. The most common initialization procedure selects the initial cluster centres randomly from input data. In this paper, a different approach to select the cluster centres by extracting the dominant colours from the colour histograms.

The second limitation associated with the K-Means (and in general clustering algorithms) is generated by the fact that during the space partitioning process the algorithm does not take into consideration the local connections between the data points (colour components of each pixel) and its neighbours. In this regard to sample the local colour smoothness, the image is filtered with an adaptive diffusion scheme while the local

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texture complexity is sampled by filtering the input image with a gradient operator.

A. *The Algorithm*

Steps in the algorithm are as follows [11]:

Step1. Choose the number k of clusters, either randomly or based on some heuristic.
Step2. Generate k clusters and determine the clusters centre.
Step3. Assign each pixel in the image to the clusters that minimize the distance between the pixel and the cluster centre (Distance is the squared or absolute difference between a pixel and a cluster centre).
Step4. Re-compute cluster centre by averaging all of the pixels in the cluster.
Step5. Repeat steps 2 and 3 until convergence is attained (for example cluster centre remains unchanged).

III. Colour Image Segmentation Using Fuzzy C-means Clustering

Fuzzy C-means (FCM) is a method of clustering which allows one pixel to belong to two or more clusters [14]. The FCM algorithm attempts to partition a finite collection of pixels into a collection of "C" fuzzy clusters with respect to some given criterion. Depending on the data and the application, different types of similarity measures may be used to identify classes. Some examples of values that can be used as similarity measures include distance, connectivity, and intensity.

A. *The Algorithm*

The Fuzzy C-Means (FCM) clustering algorithm was first introduced by Dunn [15] and later was extended by Bezdek [16]. The algorithm is an iterative clustering method that produces an optimal c partition by minimizing the weighted within group sum of squared error objective function JFCM [13]:

$$J_{FCM} = \sum_{k=1}^{n}\sum_{i=1}^{c}(u_{ik})^q d^2\,(x_k, v_i) \qquad (1)$$

where $X = \{x_1, x_2, \ldots \ldots x_n\} \subseteq R^p$ is the data set in the p-dimensional vector space, n is the number of data items, c is the number of clusters with 2 ≤ c < n, u_{ik} is the degree of membership of x_k in the i^{th} cluster, q is a weighting exponent on each fuzzy membership, v_i is the prototype of the centre of cluster i, $d^2(x_k, v_i)$ is a distance measure between object x_k and cluster centre v_i. A solution of the object function J_{FCM} can be obtained via an iterative process, which is carried out as follows [13]:

(1) Set values for c, q and Є
(2) Initialize the fuzzy partition matrix $U = [u_{ik}]$.
(3) Set the loop counter b = 0.
(4) Calculate the c cluster centres $\{v_i^{(b)}\}$ with $U^{(b)}$:

$$v_i^{(b)} = \frac{\sum_{k=1}^{n}(u_{ik}{}^{(b)})^q\, x_k}{\sum_{k=1}^{n}(u_{ik}{}^{(b)})^q} \qquad (2)$$

(5) Calculate the membership $U^{(b+1)}$. For k = 1 to n, calculate the following:
$I_k = \{i \mid 1 \le i \le c,\ d_{ik} = k_{xk} - v_{ik} = 0\}$, / I; for the k^{th} column of the matrix, compute new membership values:
(a) If $I_k = \emptyset$, then

$$u_{ik}^{(b+1)} = \frac{1}{\sum_{j=1}^{n}\left(\frac{d_{ik}}{d_{jk}}\right)^{\frac{2}{q-1}}} \qquad (3)$$

(b) Else $u_{ik}^{(b+1)} = 0$ for all $i \notin I$ and $\sum_{i \in Ik} u_{ik}^{(b+1)} = 1$; next k.

(6) If $\left\|U^{(b)} - U^{(b+1)}\right\| < \in$, stop; otherwise, set b = b + 1 and go to step 4.

IV. Colour Image Segmentation Using Density Based Clustering

Image segmentation based on density-based clustering; will integrate the spatial connectivity and the colour similarity simultaneously in the segmentation process. By this approach, pixels in a colour image will be grouped into different clusters, and these clusters form the final segmented regions of the image.

A. *Density-Based Clustering Algorithm*

Density based clustering algorithm has played a vital role in finding non linear shapes structure based on the density. Density- Based Spatial Clustering of Applications with Noise (DBSCAN) is most widely used density based algorithm. It uses the concept of density reachability and density connectivity.
Density Reachability – A point “p” is said to be density reachable from a point “q” if point “p” is within ε distance from point “p” and “q” has sufficient number of points in its neighbours who are within distance ε.
Density Connectivity – A point “p” and “q” are said to be density connected if there exist a point “r” which has sufficient number of points in its neighbours and both the points “p” and “q” are within the ε distance. This is changing process. So, if “q” is neighbour of “r”, “r” is neighbour of “s”,

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"s" is neighbour of "t" which in turn is neighbour of "p" implies that "q" is neighbour of "p".

B. Algorithmic Steps for DBSCAN Clustering

Let $X = \{x_1 x_2 \ldots \ldots \ldots x_n\}$ be the set of data points. DBSCAN requires two parameters: ε (eps) and the minimum number of points required to form a cluster (minPts).

(1) Start with an arbitrary starting point that has not been visited.

(2) Extract the neighbourhood of this point using ε (All points which are within the ε distance are neighbourhood).

(3) If there are sufficient neighbourhood around this point then clustering process starts and point is marked as visited else this point is labelled as noise (Later this point can become the part of the cluster).

(4) If a point is found to be a part of the cluster then its ε neighbourhood is also the part of the cluster and the above procedure from step 2 is repeated for all ε neighbourhood points. This is repeated until all points in the cluster is determined.

(5) A new unvisited point is retrieved and processed, leading to the discovery of a further cluster or noise.

(6) This process continues until all points are marked as visited.

V. Experimental Results

The girl image is used for this experiment because the image has different colour regions. The result of the experiments is used to find the accuracy values. The results that got by using k- means clustering is shown in the Fig. 2, in this figure we have shown the segmented image without noise (up) and with noise (down) and the original girl image is shown in figure 1.

Fig. 1 The original girl image

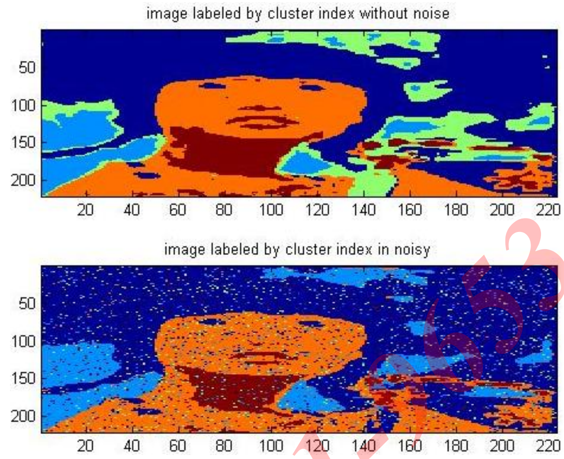

Fig. 2: Segmented girl image without noise & with noise using K-Means

Segmented girl image that we got from FCM is shown in fig. 3 that shows the segmented image without noise and with noise.

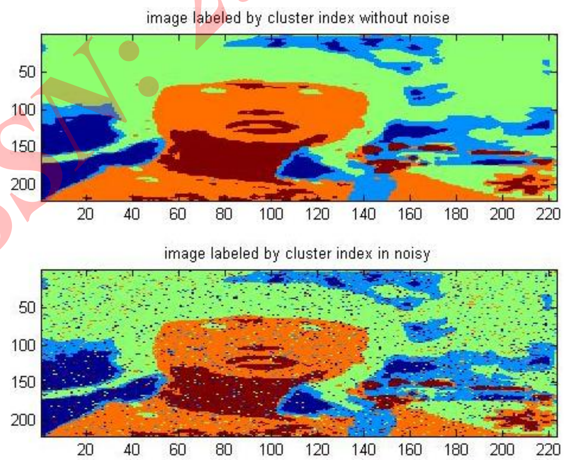

Fig. 3: Segmented girl image without noise (up) and with noise (down) using FCM

Segmented girl image that we got from density based clustering is shown in fig. 4, and segmented image with noise is shown in fig. 5.

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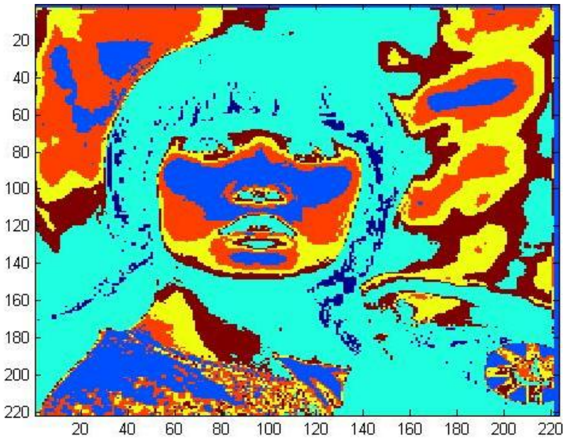

Fig. 4: Segmented image without noise using density based clustering

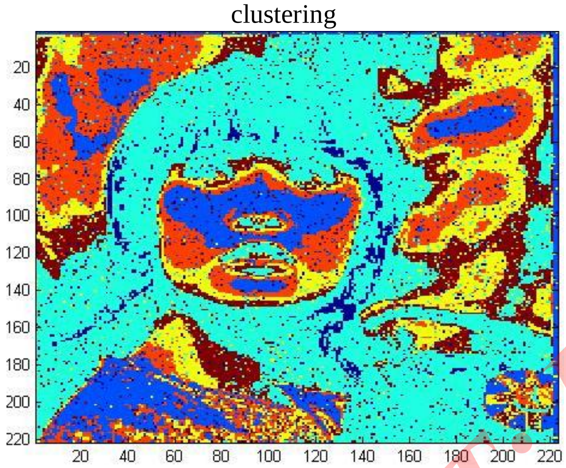

Fig. 5: Segmented image with noise using density based clustering

A. Performance Analysis

An accuracy measure for the case of segmenting images with multi - types of object. The two main considerations in defining the accuracy measure are (1).workable in cases where not all types of objects are present in each image; (2).able to count the correct and false results separately for each type of object. Suppose the image contains N types of object, then the accuracy measure is computed by

$$\text{Accuracy} = \sum_{i=1}^{N} \frac{\text{Correct segmented Pixels in } i^{th} \text{ object}}{\text{Total number of Pixels in } i^{th} \text{ object}} \qquad (4)$$

Table 1: Accuracy value of segmented girl image using clustering techniques

Method	Accuracy
K-Means	76.10%
FCM	88.83%
Density Based	94 - 96%

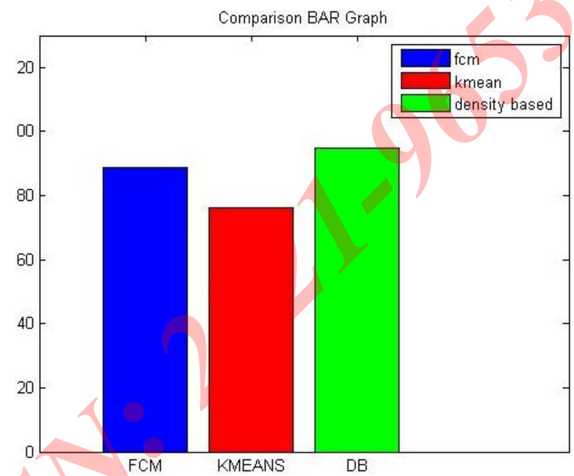

Fig. 6: Comparison of K-means, Fuzzy C-Means and Density Based Clustering Technique

The accuracy value of the density based clustering is almost 96%. It is a very good performance compared with other segmentation techniques. The accuracy value of colour image segmentation is shown in table 1. And the comparison of K-Means, Fuzzy C-means and Density Based clustering technique is shown in the bar graph given in fig. 6, by this graph we can easily see that the accuracy of density based is higher than the K-Means and Fuzzy C-Means.

IV. CONCLUSION

In this paper, a comparative study of three clustering techniques was performed. The K-Means clustering, Fuzzy C-Means clustering and Density Based clustering techniques were chosen for evaluation. Using these three techniques, the performance for different images were evaluated by calculating their accuracy. Density based clustering algorithm has played a vital role in finding non linear shapes structure based on the density. Finally, a higher performance is achieved by density based clustering compared with K-Means and FCM clustering method.

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VI. Future Scope

In future this density based clustering technique is to be applied for obtaining better performance in the applications like face recognition and shape recognition, in this we can make the clusters of different shapes and can be able to easily recognise them and can get better performance. We can also improve our performance in future by combining our density based clustering with either K-means or Fuzzy C-Means so that we can achieve our performance up to 100%.

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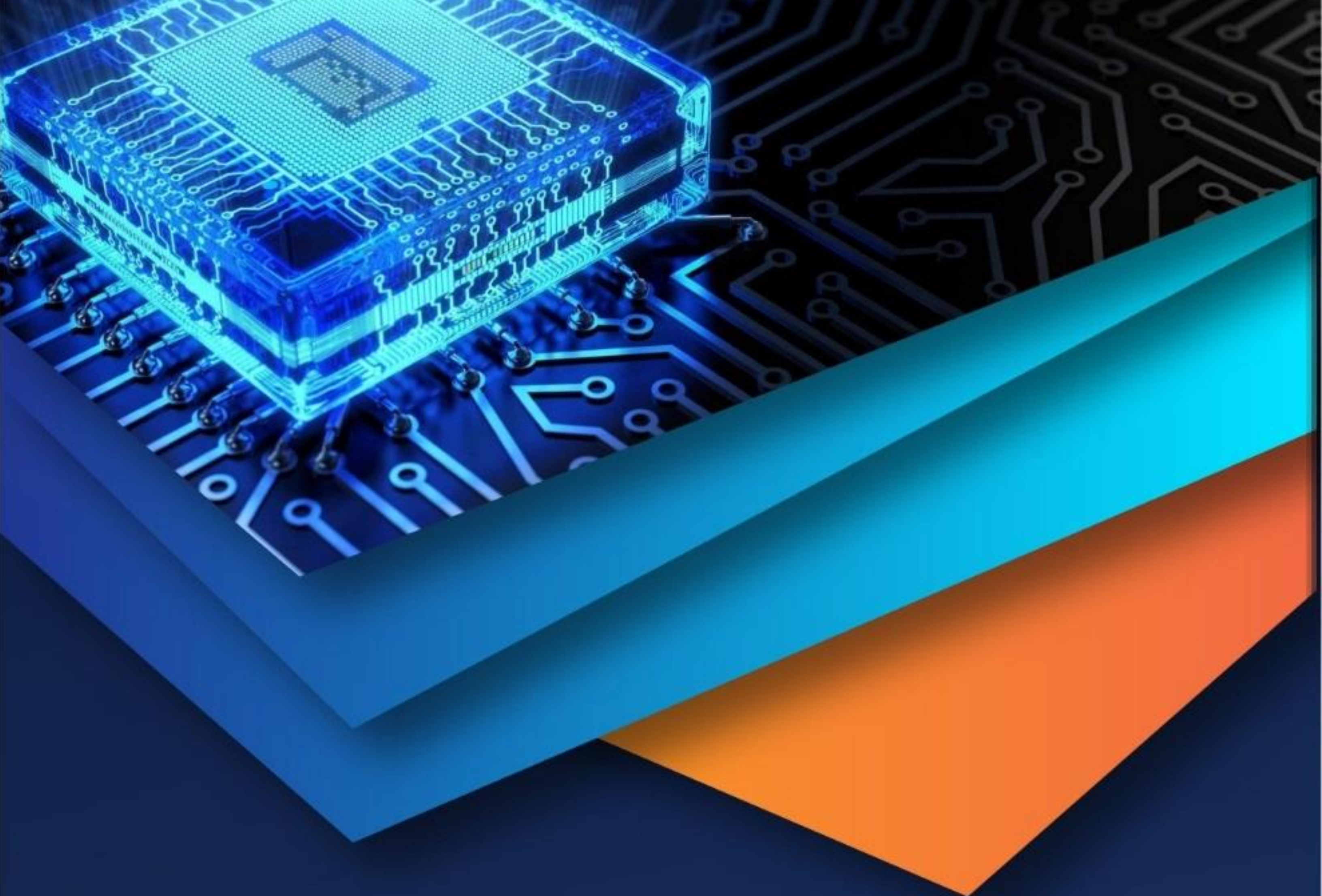

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