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Comparison and Analysis of Fuzzy Clustering Technique for Color Image Segmentation in terms of PSNR and Accuracy

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Abstract: Segmentation of an image refers to the division of pixels into homogeneous classes or clusters so that items in the same class are as similar as possible and items in different classes are as dissimilar as possible. The most basic attribute for segmentation is image luminance amplitude for a monochrome image and color components for a color image. Since there are more than 16 million colors available in any given image and it is difficult to analyses the image on all of its colors, the likely colors are grouped together by image segmentation. The clustering techniques for image segmentation using Optimal Fuzzy C means (OFCM,) and K means algorithm are being analyzed. The objective of the paper is to compare the performance of clustering techniques for color images using the Peak signal to Noise ratio (PSNR) and Accuracy.

Keywords: Segmentation, Fuzzy Clustering, OFCM, K-means clustering, segmentation Accuracy, PSNR

I. INTRODUCTION

Segmentation is a process of partitioning a digital image into multiple segments or a set of pixels and is called as image segmentation. The goal of segmentation is to simplify an image into some more meaningful segments so that it is easier to analyze. Segmentation subdivides an image into its constituent regions or objects. The level to which the subdivision is carried depends on the problem being solved. This means that segmentation should stop when an object of interest in an application have been isolated. 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. All 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 characteristics.

Segmentation has been used in a wide range of applications, with some of the most popular being, though not limited to: automatic car assembling in robotic vision, airport identification from aerial photographs, security system, object - based image identification and retrieval, object recognition, second generation image coding, criminal investigation, computer graphic, pattern recognition and diverse application in medical science such as cancerous cell detection, segmentation of brain images, skin treatment and abnormality detection of heart ventricles. Different applications require different types of digital images. The most commonly used images are light intensity (LI), computerized tomography (CT), magnetic resonance images (MRI) etc.

Fuzzy clustering techniques have been effectively used in image processing, pattern recognition and fuzzy modeling. The clustering technique used here are K-means and Optimal Fuzzy C- means clustering. The K-Means clustering technique 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, and is updated immediately after each iterative operation. Another method of Fuzzy Clustering is the Optimal Fuzzy C-Means (OFCM) algorithm. OFCM algorithm has ability to retain more information from original image than the hard clustering method. OFCM is based on distance function and membership degrees .By choosing a suitable distance function, the different clusters can be identified.

The rest of the paper is organized as follows: Section 2 deals with the steps involved in Fuzzy Clustering using K-means and OFCM and also the clustering algorithm in detailed. The performance analysis and results is shown in section 3. Finally, Conclusion of the performance results is depicted in section 4.

II. FUZZY CLUSTERING

Clustering is one of the widely used image segmentation techniques which classify patterns in such a way that samples of the same group are more similar to one another than samples belonging to different groups [2]. There has been considerable interest recently in the use of fuzzy clustering methods, which retain more information from the original image than hard clustering methods. Fuzzy C means algorithm is widely preferred because of its additional flexibility which allows pixels to belong to multiple classes with varying degrees of membership.

A. K-Means Algorithm:

K-means clustering, also known as hard c-means Clustering and is one of the simplest unsupervised algorithm

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that can be used in clustering problem. The procedure follows a simple and easy way to classify a given data set $X = \{x_1, x_2 \ldots . x_N\}$ and a uniformity predicted, P we wish to obtain a partition of the data into disjoint nonempty groups $\{v_1, v_2, v_3, \ldots . v_k\}$subject to the following conditions;

$\cup_{i=1}^{k} v_i = X$ …… [1]

$v_i \cap v_j = \varphi , i \neq j$ ….. [2]

$P(v_i) = True , i = 1,2 \ldots \ldots K$ …….. [3]

$P(v_i \cup v_j) = False, i \neq j$ …… [4]

The first condition ensures that every data value must be assign to a group, while the second condition ensures that a data value can be assigned to only one group. The third and forth condition imply that every data value in one group must satisfy the uniformity predicate while data values from two different groups must fail the uniformity criterion.

B. Optimal Fuzzy C- Means Clustering:

Optimal Fuzzy C- means clustering is an unsupervised technique that has been successfully applied to feature analysis, segmentation, and clustering. An image can be represented in various feature spaces, and the algorithm classifies the image by grouping similar data points in the feature space into clusters. This clustering is achieved by iteratively minimizing a cost function that is dependent on the distance of the pixels to the cluster centers.

The algorithms used are

Step1: Initially the centers Ci are randomly determined and iteration counter is 0.

Step2: The membership grade is μ_{ij} is calculated according to equation (1)

$$\mu_{ij} = \frac{1}{\sum_{m=1}^{c} \left(\frac{\|X_j - C_i\|}{\|X_j - C_m\|^{\frac{2}{(k-1)}}} \right)} \quad \text{---------- (1)}$$

Step3: Iteration counter is increased by 1 then, the center is calculated again using equation 2.

$$C_i = \frac{\sum_{j=1}^{N} U_{ij}^{k} x_j}{\sum_{j=1}^{C} U_{ij}^{k}} \quad \text{---------- (2)}$$

Step4: Repeat step2 and step 3 until it converges.

C. Performance Analysis:

There are various methods for calculating the performance of segmentation technique some of them are

a. Peak Signal to Noise ratio (PSNR) :

In order to evaluate the performance of different Segmentation methods, image quality measurement is required and known as the peak signal-to-noise ratio (*PSNR*). The Mean absolute Error (*MAE*) and the Peak Signal to Noise Ratio (*PSNR*) are the two error metrics frequently used to compare the quality of image. PSNR in decibels (dB) is computed by using

PSNR = 20 $\log_{10}$ (255^2 / MAE).

b. Mean absolute error (MAE):

Mean absolute error is the average of the difference between predicted and actual value in all test cases; it is the average prediction error. MAE indicates that higher the values of MAE mean the image is of poor quality.

c. Segmentation Accuracy (SA):

Segmentation Accuracy (SA) determines the eventual success or failure of computerized analysis procedures, and for this reason a considerable care is taken to improve the probability of accurate segmentation. Segmentation Accuracy is defined as

$$SA = \frac{Number\ of\ correctly\ segmented\ pixels}{Total\ number\ of\ pixels}$$

Higher the value of accuracy better will be the clustering technique.

d. Convergence rate or Execution time:

Convergence rate is defined as the time period required for the system to reach the stabilized condition. The lesser the execution time better is the clustering technique.

III. PERFORMANCE ANALYSIS

Table 1 shows the performance analysis using Clustering techniques and is observed that PSNR and Accuracy of OFCM clustering is high.

Table I: Values of segmented image using clustering techniQUE

Method	*No. of Color objects*	*Correct segmented objects*	*Accuracy*	*MAE*	*PSNR*
OFCM	7	6	85.71%	0.1428	113.33
K-MEANS	7	5.5	78.57%	0.21428	109.641

IV. CONCLUSION

A comparative study of FCM and K-means clustering technique is performed in this paper in terms of accuracy and PSNR. It is observed that fuzzy C-means (FCM) algorithm proved to be superior over the other clustering approaches in terms of segmentation accuracy and PSNR. But the major drawback of the FCM algorithm is the huge computational time required for convergence. The effectiveness of the FCM algorithm in terms of computational rate is improved by modifying the cluster center.

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