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Embedded Integration Strategy to Image Segmentation Using Canny Edge and K-Means Algorithm

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Abstract: Fusion based approaches give us ways to utilize information from one method to improve outcomes of other method. It has been found that the most of the traditional segmentation techniques can provide good segmentation results if additional information is provided to these segmentation strategies. K-means has the benefit of being a very straightforward approach that produces good segmentation outcomes. The drawback of k-means approach is that the individual using it must predict the optimal count of clusters for the image because predicted count of clusters must be provided as a parameter. Varying results can be obtained by choosing different value k. An integrated segmentation technique have been presented in this paper that combines canny edge detection based edge processing and K-means image segmentation techniques for superior output. Canny edge detector is used to find edge maps. Edge maps were obtained by searching for local maxima and hysteresis thresholding. After discovering boundaries, long edge-lines were grouped and assigned same label for predicting approximate distribution of objects in image. The count of long edges remained after edge processing is employed as parameter k to k-means segmentation process. This count was used as a constraint on k to k-means algorithm. Experimentation shows that predicted value of k using proposed method yields good k-means segmentation outcomes.

Keywords: *Image Segmentation, Canny Edge, K-means clustering*

1. Introduction

One of the most important steps in the study of digitized picture information is image segmentation [1, 2]. Its primary objective is to split an image into parts that strongly correspond to the subjects or elements of the surrounding real world. Image segmentation can be compared to the first glance we ever had at the outside world as infants. In simple terms, it is a method for viewing a picture without having a thorough understanding of the scene's objects [1, 2]. Image segmentation is observed as most important step after image pre-processing in most of the image retrieval, object recognition, Biometrics, medical image analysis, food grain quality assessment algorithms. Separating the subjects from the background is a necessary step in the process of extracting the helpful data from images or groups of pictures

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In the field of image processing, segmenting images containing natural scenes is regarded as a challenging problem. In the past few decades, many segmentation techniques have been developed, and many classification strategies for these algorithms have been proposed. However, no one algorithm is able to generate accurate results. This is particularly true if the photos were taken in various natural settings with disparate subjects [1]. The goal of this work is to increase accuracy and reliability of k-means segmentation algorithm by using an embedded integration of canny edge and k-means to divide image into parts.

Color image segmentation is basically more difficult and takes a considerable time which is complex algorithms controlled by a large set of factors [1, 2, 5]. Segmentation of color images is a significant challenge for computerized image understanding not yet completely solved. Color image segmentation is still an exciting problem due to varying texture and features in color images [1]. The goal of many interactive and parameter-controlled algorithms described in literature is to determine how many segments a picture should be subdivided into. At the present time investigators are concentrating to develop unsupervised segmentation algorithms. For autonomous approaches there

is no need of any information to partition input picture into various parts.
The chief objective of this work is to advance accuracy of traditional methods by providing additional information to guide segmentation process. There are different ways to provide additional information such as embedded incorporation and post processing. Another approach is to obtain results from different methods like boundary detection and region forming process and use edge data to improve outcomes of region forming process. Similarly embedded incorporation of edge data and k-means method can be done to predict k to k-means method [1, 3].

2. Fusion Approaches to Image Segmentation

The research area of vision in computers has grown and advanced tremendously over the last few decades. Pictures from satellites, clinical diagnosis images, iris matching, Biometrics, recognition of faces, automated recognition of vehicle license plates, CBIR Systems, human skin disease identification, and other applications have all given segmentation of pictures attention [1 - 8]. Numerous techniques have been evolved in last four decades. Segmentation-algorithms can provide satisfactory results for particular applications. But there is no generalized technique that can provide satisfactory outcomes for all kinds of pictures. If additional guidance is provided to traditional segmentation procedures, these algorithms can produce worthy segmentation outcomes.
Some proposals try to use edge data to overcome these problems [9]. Based on how this information is applied, two distinct trends can be recognized [1, 9]:

2.1. Embedded Integration

Prior processing technique that is most established contains retrieving edges first and then using edge data to improve the accuracy of traditional segmentation procedures. The basic framework of the approach is shown in fig. 1 [1, 9]. The operation of finding edges and processing yields extra information that may be applied as a criterion for decision-making in the region-growing and k-means segmentation procedures. For example, edge information can be used to determine region development seeds to region growing algorithms whereas edge data is used to forecast k to k-means segmentation.

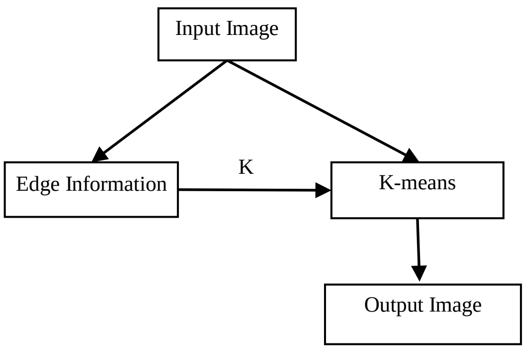


Fig. 1. Embedded Integration Strategy

2.2. Post Processing

In post processing procedures, segmentation outcomes are obtained by employing edge dependent and region dependent methods separately [9]. After the image has been treated individually using both edge-based and region based methods, boundary information is used to improve region-growing results [9]. First, as shown in Fig. 2, boundary and region segmentation outcomes are obtained independently. Through a posteriori fusion procedure, the initial segmentation obtained by one technique is then adjusted or improved utilizing both types of information.

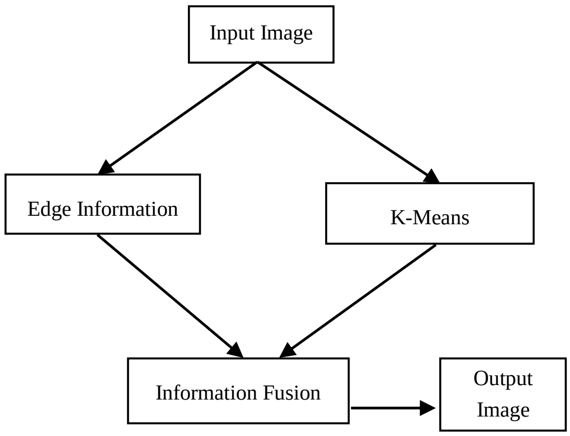


Fig. 2. Post Integration Strategy

2.3. Integration in Clustering Algorithms

Rose H. Turi [11] mentions clustering methods in his thesis. The majority of widely used clustering-based segmentation techniques are C means, K-means, fuzzy K-means, thresholding, and snob approaches. The usual failure of most clustering is the requirement for a particular number of the clusters, a value that must be given as input. Turi [11] proposed a procedure for robotically calculating the count of groups based on the inter-class distance metric.

3. Clustering

An input dataset is substituted by clusters that have groups of data items with comparable features, during the operation of clustering. Image segmentation is often identical to clustering, that clusters pixels with the same color, grayscale, or other attributes. The two primary categories of clustering approaches are (1) partitioned clustering and (2) hierarchical clustering. There are various subcategories and algorithms within each of the primary clustering approaches. [12].

The procedure of clustering is one that is often used in imagery segmentation. Many clustering techniques exist, for example (1) k-means, (2) Rough Fuzzy, (3), and (4) IFCM (5) Adaptive (adjustable) K-Means. An autonomous method utilized to separate the desired region from the scenery is known as K Means. The elements in data are distributed or grouped across K-clusters [12, 13]. Typically, hierarchical techniques and partitional strategies are used to categorize clustering techniques

3.1. Hierarchical Clustering

A clustering technique called hierarchical clustering is employed to group comparable data elements. Both the top-down or bottom-up approach to clustering is used in hierarchical-clustering.

3.1.1. Agglomerative Clustering

This method, which is hierarchical, divides the information elements into distinct groups at the beginning of the clustering process before combining the relevant segments into one larger cluster. In hierarchical techniques, calculating the distance between elements is an essential stage. Dendograms may be employed to show this procedure. This approach leads to multiple divisions as the outcome. The least unlike data elements are indicated by the lowest entry in the dissimilarity vector, which makes them potentially suitable for merging. The resulting matrix is used to determine which groups should be combined [16, 17, 18].

3.1.2. Divisive Clustering

Divisive method is contrast to the scheme designated in earlier section. The data elements are grouped together to single, large cluster, and then they are gradually divided into small size, diverse clusters until each data element becomes part of its self-cluster. They are very excellent at spotting big groupings. The method is superior than clustering by agglomeration and adheres to a top-down strategy. However, none of the main platforms provide a specified the execution for it because of how complicated it is to develop [19-26].

3.2. Partitional Clustering

The way this method operate is by first defining total groups first and then to merging repeatedly. The data elements are divided to clusters via partitional-clustering so that the difference between each cluster's center and the data element is kept to a minimum. K-means is the name of the method used to do this. The picture is divided into a single partition as a consequence of partitional clustering. This clustering method is categorized into two: Hard and Soft. The process of hard clustering involves assigning every piece of data-element to a specific cluster. K-Means, C-Means and Spectral methods are hard clustering methods [27-30].

3.2.1. K-means Clustering

Mac Queen devised this algorithm. This continues to be usually employed in a number of studies, together with picture segmentation, pattern recognition, and data processing. This autonomous clustering technique [11] divides the supplied information points into numerous categories according to their intrinsic separation from one another and by using a predetermined number of clusters (let's say k). Near centroids, these data-points are grouped together. A distance metric is used to allocate each pixel in the picture to the adjoining clusters center. The K centers gradually relocate up until the final modifications are made.

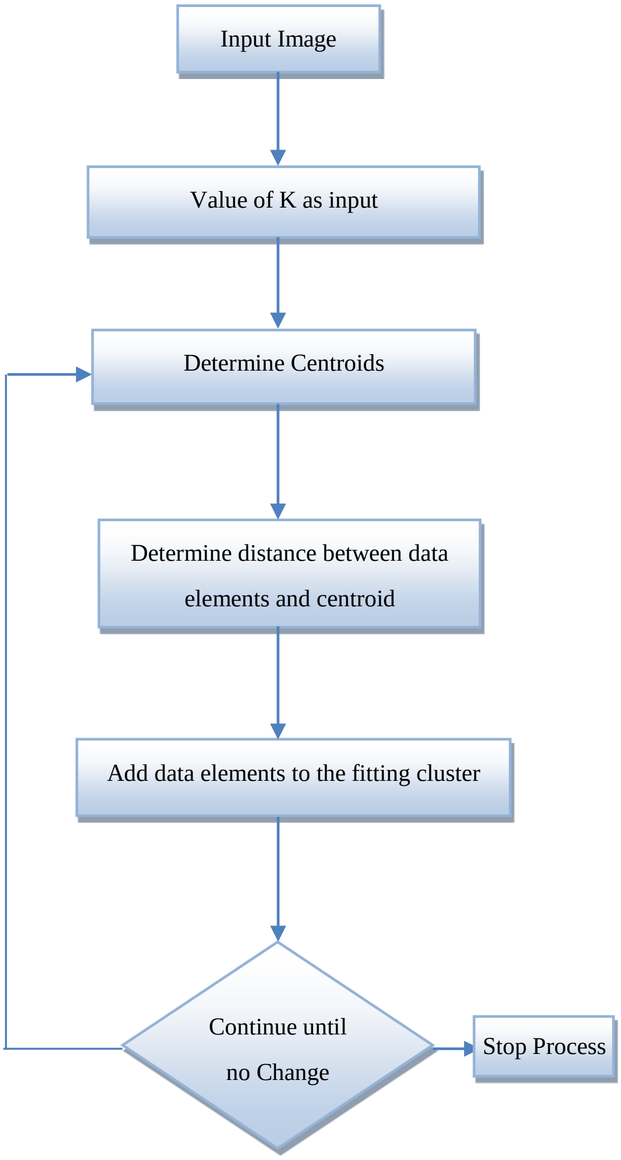


Fig. 3. K-means Clustering

3.2.2. Mean Shift

A straightforward, adaptable, and reliable approach to grouping data elements is mean-shift. It relies on the estimator of kernel density technique, which calculates the basic dispersion for an individual population. The process's fundamental idea is to iteratively allocate the information values to the designated clusters by moving them to the direction of the greatest density or maximum of data values. It is applied during the segmentation of imagery [17

3.2.3. Fuzzy C-Means

The study pixels in this approach may belong to more than one cluster with various affiliation coefficients. The fuzzy partitioning matrix (FPM) approach [29] is iterative by design and needs both an objective function and a cluster center. Each cycle updates the numbers for the cluster center and objective function, which are terminated when the deviation among the two succeeding object function values is smaller than a predetermined cutoff.

3.2.4. Rough Fuzzy C-Means

Maji and Pal [] presented a c-means method called rough-fuzzy c-means (RFCM), which incorporates concept of fuzzy as well as rough sets. The RFCM extends the c-means method by including the notion of fuzzy memberships of fuzzy collections and smaller and higher estimates of rough clusters.

4. Predicting k to K-means Image Segmentation

This thesis uses an innovative technique for color-based image segmentation employing embedded attributes. This work uses an embedded integration strategy that employs canny edge based procedure to forecast value of k to k-image segmentation technique. Edges in image are first retrieved using canny edge operator. Then these edge maps are further processed to determine distribution of objects in image. To achieve effective segmentation outcomes, different types of methods, containing finding edges, edge handling, and k-means are med.

4.1. Canny Edge Detection

A variety of real boundaries in image may be found with the canny edge-detector [31, 32, 33]. Since noisy pixels produce misleading edges, the detection algorithm gets rid of the undesired noisy pixels by smoothing the image's lines. When contrasted to traditional edge detection techniques, the signal-to-noise (SNR) ratio is better with this particular edge finding.

To minimize the impact of noise, the picture is first smoothed using an appropriate filter. After that, each point's local gradient and boundary directions are determined.

-1	0	1
-2	0	2
-1	0	1

GR_x = x-direction kernel

-1	-2	-2
0	0	0
1	2	1

GR_y = y-direction kernel

Fig. 4. Canny Operators

The Gradient magnitudes can be determined similar to Sobel operation method as follows [31, 35] -

$$|GR| = \sqrt{GRx^2 + GRy^2} \quad (1)$$

$$|GM| = |GRx| + |GRy| \quad (2)$$

The direction of edges shall be stored as shown in equation

$$\theta = \operatorname{atan}\left(\frac{|GRy|}{|GRx|}\right) \quad (3)$$

These edge points give birth to peaks in the gradient's measure. This location has highest intensity in the slope's path. As the boundary-detector travels along the peak of these contours, it sets value of pixels to zero that are not actually on peak of the edge. Consequently, a narrow line appears in the output,

Two cutoff values-upper cutoff (C2) and lower cutoff (C1) are used to threshold these contour pixels. Ridge pixels are categorized as either solid edge pixels or weaker edge pixels depending on whether their values are higher than the upper cutoff (C2) or between the lower threshold (C1) and the upper cutoff (C2). Lastly, via finding the weaker picture elements that are related toward the solid pixels, the image's edges are joined.

Advantages

- Improves SNR
- Better Detection

Disadvantages

- Time Consuming
- Complex calculations
- False Zero Crossing

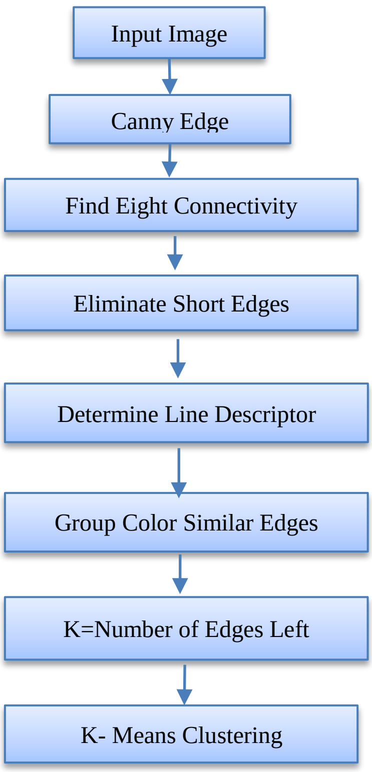


Fig 5. Predicting K to K-means Image Segmentation

The process of determining k to k-means image segmentation using embedded integration of canny edge is summarized in fig. 4 [3, 4]. Longer edges reflect an approximate sense of the object's arrangement in the picture. But edge detection results in broken, discontinuous edges due to complex texture of image. So it becomes essential to link these edges or assign them similar label to predict value of k. Eight connectivity of binary image is determined. Connected components in edge map are labeled. HSV color information of each connected component is determined. Line descriptor of each edge-segment is obtained as follows –

$$Li = [\text{HSV Color Values, Percentage}] \quad (4)$$

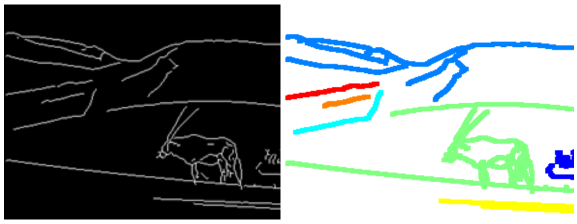
Percentage is the ratio of number of pixels on Line i to the total number of pixels in image.

Edge is discarded if its pixel count falls below a certain level. Every edge's mean color is computed. Color similarity between edges is determined using Euclidean distance and color similar edges assigned same label. Number of edges left after assigning identical label to color like edges is considered as value of k to k-means image segmentation.

5. Experimental Results

In this section, we present experimental results on segmenting synthetic, natural images using integrated approach that utilizes canny edge based approach to forecast k to k-means segmentation algorithm. MATLAB graphical user interface is developed to visualize results. Firstly, image is converted into gray scale. To reduce impact of noise, Gaussian filter is applied. Edge maps were obtained using canny edge operator. Connected edge components were determined. Label is assigned to each connected component and mean HSV color of each connected component is computed. Small length edges were removed depending number of pixels in edge. Color similarity of longer boundaries is determined using Euclidean distance. Color similar boundaries assigned same label. Number of boundaries left after assigning identical label to color similar edges is considered as parameter k to k-means algorithm. Final segmentation outcomes are obtained using k-means procedure with predicted value of k as parameter to K-means process.

(a) (b)



(c) (d)

Fig 6. (a) Original Image (b) Canny edge map (b) Eliminating Short Edges (d) Color Similar Edges

To evaluate performance of K-Means method, predicted number of clusters by using embedded integration strategy is compared with number of clusters in ground truth. It is found estimated numbers of clusters are close to actual clusters in ground truth image.

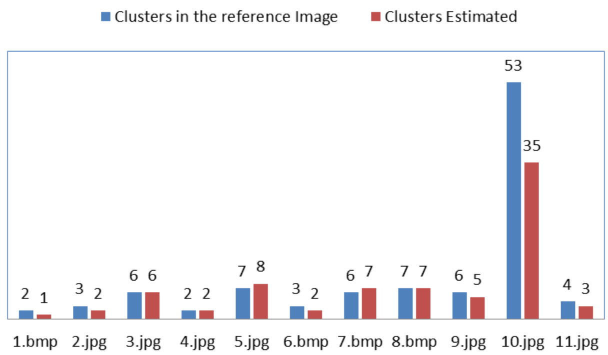
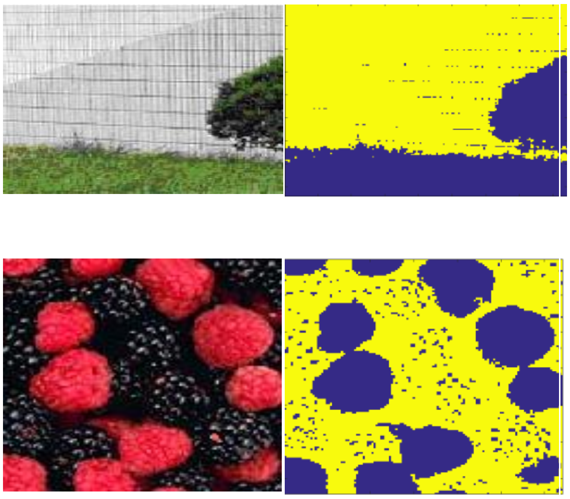


Fig. 7. Clusters in Ground Truth and Estimated number of clusters

Segmentation algorithms were tested on variety of complex natural images representing different classes, for example nature scene, flowers, animals, texture images etc Fig. 8 shows the results of proposed algorithm.



(a) (b)

Fig. 8. (a) Original Image (b) Segmentation outcome

6. Conclusion

The diversity of the intensity, surface, and shape in general-use images of nature makes autonomous segmentation a difficult task. In the context of the segmentation of complicated imagery like outside and natural scenes, that contain extra challenges because of effects like lighting, regions of interest, non-regular sunlight, or structure, it is frequently tough to achieve satisfactory outcomes by employing only a single of these methods. The primary drawback of the k-means algorithm is the requirement that an input value, k, be supplied. The quantity of the variable k determines how well the k-means color picture segmentation works. K-means may deliver positive outcomes if the total quantity of clusters is accurately approximated. This paper proposes a reliable border detection-based approach to calculate the total count of clusters autonomously. K-means segmentation algorithm produces good outcomes using estimated value of k using proposed method.

Author contributions

Rajendra V. Patil: Conceptualization, Methodology, Software, Field study, Data curation, Writing-Original draft preparation, Software **Dr. Renu Aggarwal**: Validation, Supervision **Govind M. Poddar:** Visualization **Dr. Mahua Bhowmik:** Investigation. Validation **Mahadev K. Patil:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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